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Journal

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AMERICAN WATER WORKS ASSOCIATION

Gavel Wielder, 1949–1950
President A. P. Black

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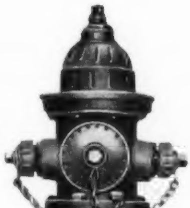

COMING MEETINGS

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14–16—Pennsylvania Section at Penn-Harris Hotel, Harrisburg, Pa. Secretary: L. S. Morgan, Dist. Engr., State Dept. of Health, Greensburg, Pa.

22–23—Rocky Mountain Section at Acacia Hotel, Colorado Springs, Colo. Secretary: O. J. Ripple, Ripple & Howe, Cons. Engrs., 426 Cooper Bldg., Denver 2, Colo.

25–27—Missouri Section at Connor Hotel, Joplin, Mo. Secretary: Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

28–30—Michigan Section at Park Place Hotel, Traverse City, Mich. Secretary: Raymond J. Faust, Div. of Water Supply, Bureau of Eng., Michigan Dept. of Health, Lansing 4, Mich.

October **6–7**—Iowa Section, Burlington, Iowa

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11–13—Arizona Section, Yuma, Ariz.

14–16—Florida Section, Orlando, Fla.

17–19—New Jersey Section, Atlantic City, N.J.

December **5–7**—Southeastern Section, Albany, Ga.

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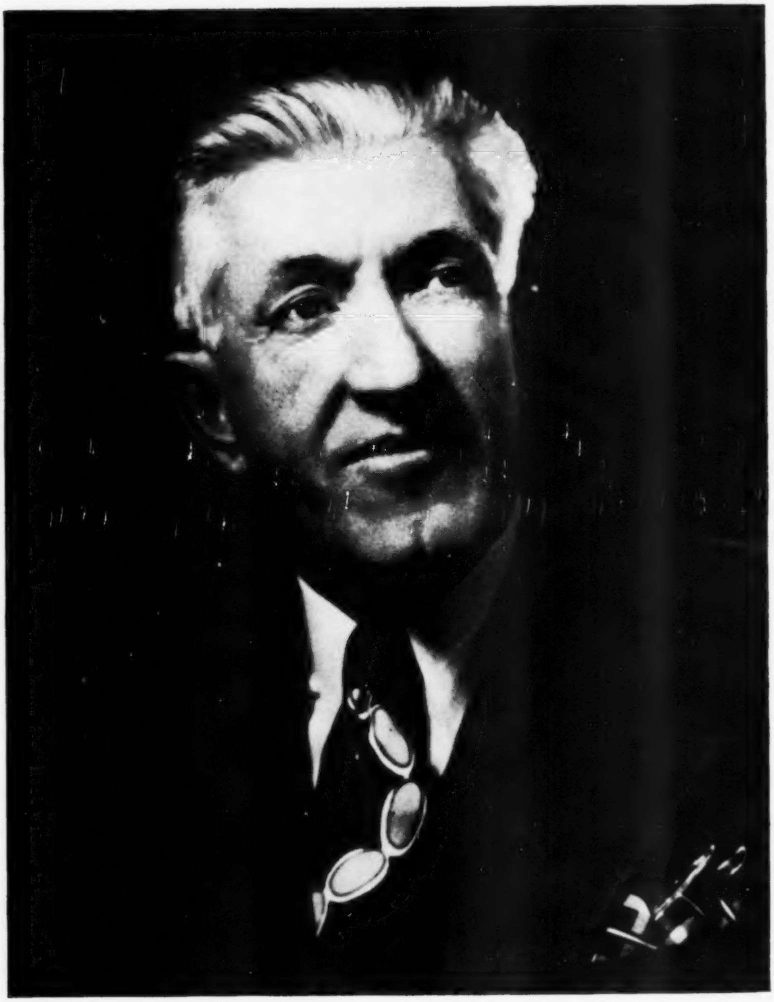

A. P. Black, President 1949–1950

Journal

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Simplified Bookkeeping System for Small Water Companies

By George J. Natt

A paper presented on April 28, 1949, at the New York Section Meeting, Elmira, N.Y., by George J. Natt, Sr. Civ. Engr., Water Power and Control Commission, Albany, N.Y. Before becoming associated with the latter organization, the author served for eleven years as a hydraulic engineer on the staff of the New York State Public Service Commission.

THE Public Service Commission of New York, by provision of the Public Service Law, has jurisdiction over all privately owned water companies with a value of $10,000 or more. At present there are approximately 95 such companies, operating about 113 plants, under Public Service Commission jurisdiction.

All companies having annual revenues of over $15,000 are required to keep double-entry books under systems of accounts prescribed by the commission. The commission, however, has promulgated no bookkeeping system for Class *E* companies (those having annual revenues of less than $15,000), nor has it recommended a bookkeeping system for them.

Of the approximately 95 companies under commission jurisdiction, about 68, or approximately 71 per cent, have annual revenues of less than $15,000; and of these, half have revenues of $5,000 or less. A substantial portion of these small companies are one-man affairs; that is, the principal stock is held by one individual, who has the responsibility of operating the firm. All of these companies are in rural areas and represent merely a sideline to a more gainful occupation of the "owner." Although all the operators are mechanically inclined, few are versed in keeping books.

From the very beginning of the author's association with these Class *E* water companies, he was repeatedly requested to formulate, for many of them, a bookkeeping system which would be simple and adequate for their needs and at the same time be sufficient for compiling the various governmental reports. The bookkeeping sys-

tem presented in the Appendix is the result. Work on it was started some time ago and was completed during the author's tenure with the Public Service Commission.

The system is an adaptation of one invented for small telephone companies by Ward E. Hinman, Chief Telephone Engr. of the Public Service Commission. Hinman's system, which received favorable comment at a national telephone convention, has been voluntarily adopted by many small telephone companies and used with great success. In a number of these companies the girl handling the switchboard also does the bookkeeping. Only one book is involved, which provides for receipts and disbursements, a summary of revenues and a summary of salaries and wages.

With the exception of the revenue summary sheet, only the transactions during the current year are to be recorded, figures from one year not being carried over to the next. The Public Service Commission report serves as the annual statement of the company's affairs and serves also as the control for this bookkeeping system.

Bookkeeping is necessary for two basic reasons: first, so that the owners and management may be accurately informed of the company's financial condition and of the results of its operations; and second, so that the many governmental reports may be made accurately and easily. The objective has been to develop a bookkeeping system which will meet these requirements and which can be maintained without any expert accounting knowledge. It is applicable to individual owners of water plants, as well as to corporations. Reduced to its fundamentals, bookkeeping means keeping account of where the money comes from and where it goes. For these two basic purposes five forms, kept in a single loose-leaf binder, have been designed.

Customer Ledger

The customer ledger form provides a record of customers, their water facilities, billing, payments, discounts and allowances, accounts receivable and uncollectible operating revenues. This form is in two parts: the so-called ledger portion and the billing portion.

Each customer (including public fire protection and other federal, state or municipal use) requires a line across the customer ledger. The customers are to be listed alphabetically, leaving a few spaces between initial letter groups for additions. If the majority of the customers are billed quarterly but a few large customers are billed monthly, three lines should be provided for each customer billed monthly, one line to be used for each month in the quarter. The fly or narrow leaves headed "Current Billing" (six of which are required for monthly billing and two for quarterly billing) when filled should be transferred to a storage binder and new leaves inserted. The "Customer Record" pages may continue to be used until there have been sufficient changes on them to warrant rewriting. Identical "Customer Record" pages should be kept in the storage binder so that fly leaves when inserted will be readily usable in retracing former charges to an individual customer. The customer's account numbers on the "Current Billing" leaves will facilitate their insertion at the correct location in the storage binder.

The instructions in the Appendix give information on how to use each

of the columns in this form. In the author's opinion, the "Fixtures for Unmetered Billing" section will be most helpful, as it gives a ready record of the basis for the flat-rate bill. Experience has shown that many small companies have no definite knowledge of the customers' premises, and since the plant owners could not take time for an inspection, the bill was based on what fixtures were thought to be present.

Because all companies under commission jurisdiction are now required to own and maintain service lines, the columns for size and ownership of services will be of great assistance. This information is often lacking in the records of small companies.

Disbursement Ledger

The disbursement ledger provides a record of all expenditures for operation, maintenance and repairs, construction of water plant and other purposes. It affords a simple means of recording and distributing expenditures to proper expense, water plant or other accounts. On the disbursement ledger pages for any year are recorded only the transactions *during that year*.

A glance at the form will indicate the ease with which disbursements are distributed to the proper accounts. The left-hand sheet contains the expense accounts, and the right-hand sheet, the plant accounts, depreciation reserve, taxes, notes and accounts payable, interest and dividends. In designing the form, columns were provided for only the six plant accounts most frequently used. Entries of costs in other plant accounts are made by using the column marked "Other Water Plant Installed." Thus, with this form, a disbursement is correctly distributed using only one entry.

A word of caution should be said about the column headed "Depreciation Reserve." This column is not to be used for accruals to the reserve account. Annual accruals to depreciation reserve are entered in the annual report to the Public Service Commission, which, as previously stated, is the control for this bookkeeping system. The "Depreciation Reserve" column in the disbursement ledger is used only when a payment is made that directly affects the account. For example, suppose that a new truck was purchased and a trade-in allowance of $200 was received on the old one. To enter correctly the full cost of the new truck in the water plant account, the trade-in allowance is entered in the reserve column in red. This will balance out the payment when the check is entered in the ledger. It is not recommended that retirements be entered during the year except when an item of equipment, or the like, is sold and a trade-in allowance received. All other retirements are to be made at the end of the year.

For year-end closing of the ledger, all unpaid bills on hand should be entered. These are to be distributed to the appropriate accounts, but instead of entering the amount in the "Total Amount" column, the amount of the bill is entered in red in the "Notes and Accounts Payable" column. Since the bills are not yet paid, they are marked "Distributed" to avoid duplicate distribution and are carried over for payment in the next year. When actually paid, the amount is entered in black in the "Total Amount" column and in black also in the "Notes and Accounts Payable" column.

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CUSTOMER LEDGER
CUSTOMER RECORD

Acc't No.	Name	Address	T.D No.	Deposit Date	Deposit Amount	Sr Cl.	Fixtures for Unmetered Billing: S	T	W	B	L	F	H	Other	Period Total	Meter* Size	Make & No.	Date Tested	Lgth & Kind	Service Line Data Size & Ownership: 1/2"	3/4"	1"	Other
421	Tobin, John	16 Oak St	1		–	1	1/2.00	1/1.25	1/.25	1/1.25	2/.75	–	1/2.50		8.00				15' Cop		Co.		
422	Thompkins, E.K.	100 Leonard St	1		–	1	1/2.00	1/1.25	1/.25	1/1.25	2/.75	–	–		5.50				15' Cop		Co.		
423	Town, Earl	2 South St	1		–	1	1/2.00	2/1.90	2/.50	2/1.90	–	–	1/2.50	Wash Mach. .75	9.55				20' G.I.		Cus		
424	Town Dairy	62 Main St.	1		–	2										2"	Trident 4,462,661	4/13/43	50' C.I.				2" Co
425	Townsend, H.R.	66 Dove St	1		–	1	1/2.00	1/1.25	1/.25	1/1.25	2/.75	1/.50	–		6.00				20' Cop		Co		
13	Tracy, Arthur	50 Lawrence St	2	4/6/44	10.00	1	1/2.00	1/1.25	1/.25	1/1.25	2/.75	1/.50	1/2.50		8.50				32' Cop		Co		
22	Turner, S.E.	314 Pine St.	2	5/12/44	10.00	1	1/2.00	2/1.90	2/.50	2/1.90	2/.75	–	1/2.50		9.55				25' G.I.		Cus		
426	Tweed Iron Works	120 Main St	1		–	2										1"	Empire 2,726,610	3/20/42	50' G.I.			Co	

Fig. 1. Customer Ledger —Left-Hand Page

CUSTOMER LEDGER
CURRENT BILLING

Period Sept. 1-Nov. 30 Year 1945

Page B. 20

Acc't No.	Balance Due	Current Billing — Metered Sales: Present Reading	Consumption	Current Bill	Unmetered Sales	Sales for Public Fire Protection	Other Operating Revenue: Item	Amount	Total Bill	Disc. and Adj.	Paid: Date	Amount
421		(1 month pro-rata. House closed)			2.70		Turn-on	2.00	4.70	.27	12/8	4.43
422					5.50				5.50	.55	12/10	4.95
423					9.55				9.55			
424		16,213,000	1,800,000	117.96					117.96	4.24	12/6	113.72
425	2.00				6.00				8.00	.60	12/7	7.40
13					8.50				8.50	.85	12/7	7.65
22					9.55				9.55			
426		912,000	66,000	12.96					12.96	1.09	12/10	11.87

Fig. 2. Customer Ledger —Right-Hand Page

Operating Revenues Summary

The operating revenues summary sheet, which can be kept in front of the customer ledger section, provides a monthly or quarterly and annual summary of customer billing, collections and accounts receivable, as well as a record of other receipts. This form, it will be noticed, is quite similar to the "Current Billing" sheet.

Salary and Wages Summary

The salary and wages summary affords a record required by federal social security tax regulations. The form has been designed so that the wages of employees may be combined for entry in the disbursement ledger, while wages data for the old-age benefit and unemployment insurance tax, the withholding tax and other reports may also readily be available.

Weekly Labor Report

The last form provided is a weekly labor report, consisting of pocket-size sheets on the face of which plant employees record the division of their time between operation, maintenance and repairs and water plant activities, and on the reverse side, the units of property installed and retired.

Acknowledgment

Acknowledgment is due to J. P. Redwood, Chief Hydraulic Engr., New York State Public Service Commission, and to his assistant, W. R. Wolff, for their aid in the preparation of this bookkeeping system.

APPENDIX

Instructions on the Recording of Current Transactions by Small Water Works Corporations

The bookkeeping system herein outlined is designed for use by water works corporations having annual revenues of less than $15,000. The boldface headings below refer to the various forms which are illustrated in the accompanying Fig. 1–8. The italicized headings correspond to the major column headings on the forms shown. These instructions are supplemented by the explanatory material on the preceding pages, as well as by the Notes which appear at the end of this Appendix.

Customer Ledger—Customer Record Page

Since "Customer Record" pages are to be used until such time as they need extensive revision, they should not be numbered in series with the "Current Billing" pages. After the word "Page" on the customer record sheet (Fig. 1) the letter "R" has been printed. All customer record pages should be numbered in series: R1, R2, etc. Likewise, on the "Current Billing" page (Fig. 2) the letter "B" has been printed. Current billing pages should be numbered in series: B1, B2, etc.

Instructions on the entries to be made in each column are given below.

Acc't No.

Enter the *account number* of a customer at one address (service location). If a customer moves or discontinues service at that location, this number becomes dead and should not again be used. (As a result, the names listed alphabetically will not necessarily have consecutive numbers.)

Name

Enter name of customer.

Address

Enter address of service location. If bill is sent elsewhere, a note to that effect should be made.

T.D. No.

Assign numbers to the *tax districts* in which the company has customers and enter such numbers in this column.

Deposit

If a deposit is received from a customer, enter in this column the date received and the amount. This will facilitate the computation of interest. When the deposit is returned, in whole or in part, circle the previous data in this column with red ink and enter therein (in red) the date the deposit was returned and the amount returned. Also make a notation such as "deposit refunded" any place along the line allotted to that customer.

The actual cash returned to the customer is to be recorded on the disbursement ledger; i.e., the name of the customer in "Description" column; number of check in "Ck. No." column, or "C" if cash; the amount in "Total Amount" column; and the same amount in "Miscellaneous" column.

Sr. Cl.

Enter the number of the *service classification* in the company's filed rate schedule under which the customer is served. If more than one, include all.

Fixtures for Unmetered Billing

In each of the subcolumns insert the number of the various fixtures that form the basis of the customer's bill. For example, under "S," the entry "2/2$\underline{^{50}}$" means 2 sinks at $2.50. In the "Period Total" subcolumn enter the total bill for the billing period, based on the fixtures listed. S stands for sink; T, toilet; W, washbowl; B, bathtub or shower; L, laundry tub; F, faucets, inside or out; H, hose connections; Other, any other fixture charged for but not listed (including private fire protection). If the customer is billed on a meter rate, this entire column is left blank.

Meter

Enter the size of the meter, followed by an asterisk (*) if customer owned; the make and manufacturer's number; and the date on which the meter was last tested (enter this date with *soft pencil*).

Service Line Data

Under the subcolumn headed "Lgth. & Kind," enter the length of the service line from main to territorial limit of street; i.e., the length which the company is required to own and maintain. Also show the kind of pipe—copper, "cop."; cast iron, "C.I."; galvanized iron, "G.I.," etc.

Under the "Size & Ownership" subcolumns, enter the size of service line and whether company or customer owned. This information can be indicated in one step by inserting "Co." or "Cus."—for company or customer owned—in the appropriate place. Under "Other," show the size of services larger than 1 in. and their ownership.

Customer Ledger—Current Billing Page

Instructions on the entries to be made in each column of the "Current Billing" page are given below.

Acc't No.

Enter the same account number as on the "Customer Record" page.

Balance Due

Enter the unpaid balance from previous period. (If a credit, enter in red.)

Metered Sales

Enter sales computed at scheduled rates.

Unmetered Sales

Enter the period total shown under "Fixtures for Unmetered Billing," in-

cluding sales for private fire protection.

Sales for Public Fire Protection

Enter amounts billed for the period.

Other Operating Revenue

Show under "Item" the service for which the charge was made; for example, "turn-on," "repairs on frozen meter," "rents."

Total Bill

Enter the total of metered and/or unmetered sales, the amount under "Other Operating Revenue" plus the unpaid balance due (for individual customers). Billing for "Public Fire Protection" should also be shown in the total.

Disc. and Adj.

Enter the prompt-payment *discount* (if any) and any other *adjustments* on the amount as billed; also credit for interest on deposits. This entry is to be made, of course, when the bill is paid.

Paid

Under "Date," enter the date on which payment is made, and under "Amount," the amount paid.

Disbursement Ledger

Instructions on the entries to be made in each column of the "Disbursement Ledger" (Fig. 3 and 4) are given below.

Date

For expenditures, enter the date of payment; for other entries, the date of the entry.

Description

Show to whom and for what payment is made.

Ck. No.

Enter the *check number* if payment is made by check; "C" if payment is by cash; "AP" (accounts payable) or "NP" (notes payable), if payment is not made at time of entry.

Total Amount

Enter the total of each expenditure. The subamounts distributed in subsequent columns must total to this amount.

Water Source, Pumping and Purification Expense

In the subcolumn "Labor," enter the cost of labor taken from the "Weekly Labor Report" (*see* p. 491).

Under "Materials & Supplies," enter the cost of materials and supplies purchased for the operation, repair or maintenance of the water source, pumping and purification plant. Materials and supplies purchased for a particular job of replacement or new construction should not be included herein but in the appropriate "Water Plant" subcolumn of the disbursement ledger (*see also* Note 3, p. 494).

Under "Power or Fuel Purchases," enter the cost of all electric power used for pumping or lighting the water source, pumping or purification plant and the cost of fuel (such as gas, gasoline, oil or coal) for engines used in connection with the water source, pumping or purification plant.

Under "Other Expense," enter any other expenses in connection with the water source, pumping and purification not provided for elsewhere.

Transmission and Distribution Expense

In the subcolumn "Labor," enter amounts for labor employed in the repair and maintenance of mains, services, meters, meter installations and fire protection plant (hydrants) taken from the "Weekly Labor Report."

Under "Materials & Supplies," enter the cost of materials and supplies used in the repair and maintenance of mains, services, meters, meter installations and fire protection plant (hydrants). If the materials and supplies are purchased directly for a repair job, the cost thereof is

Date		Description	Ck. No.	Total Amount	Water Source Pumping and Purification Expense: Labor	Materials & Supplies	Power or Fuel Purchases	Other Expense	Transmission and Distribution Expense: Labor	Materials & Supplies	General Expense: Office Salaries	Other Gen'l Expense
1945												
		Totals brought forward		4438 59	936 29	452 67	149 02	26 14	319 32	116 56	2200 00	52 20
Dec	10	Gould Pump Co.-Inv 12/3. New Pump	423	570 21								
	10	Freight on Pump	424	15 00								
	12	Le Valley & Co.-Copper Pipe & ftgs	425	198 32						25 06		
	12	Sunbeam Chem. Co-Chlorine	426	51 16		51 16						

FIG. 3. Disbursement Ledger—Left-Hand Page

Water Plant: Mains	Services	Meters	Hydrants	General Equipment: Transport	Other	Other Water Plant Installed: Name of Acc't	Am't	Depreciation Reserve	Taxes: General	Income	Notes and Accounts Payable	Interest	Dividends	Miscellaneous
0 00	0 00	0 00	0 00	0 00	0 00	0	0 0	0 00	20 21	113 19	–	57 99	–	–
						Pump Equi.	570 21							
						"	15 00							
	173 26													

FIG. 4. Disbursement Ledger—Right-Hand Page

Billing Period	Balance Due	Current Billing: Metered Sales	Unmetered Sales	Public Fire Protect Sales	Other Oper. Revenues	Current Billing Plus Bal.	Discounts and Adjustments	Payments during Period	Uncollect. Operating Revenues	Other Receipts: Date	Items	Amount
Mar. 1945	142 10	1012 62	902 15	2000 00	5 00	4061 87	101 06	3876 42		3 16	Rent for storage space	30 00
June 1945	84 39	1106 16	910 25		2 00	2102 80	96 60	1886 04		5 15	Sale of Timber	150 00
Sept 1945	120 16	1220 13	945 50		–	2285 79	102 15	2045 64				
Dec 1945	138 00	1264 61	970 25		17 15	2390 01	116 01	2104 59	30 50			
Total for 1945		4603 52	3728 15	2000 00	24 15	10840 47	415 82	9912 69	30 50			180 00

FIG. 5. Operating Revenues Summary

to be entered herein. If the items for repairs are taken from stock on hand the cost is to be entered in red in the water plant account column to which it was originally charged and entered in black in this column (*see* Note 3). Materials and supplies purchased for a particular job of replacement or new construction should not be included herein but in the appropriate water plant column.

General Expense

Enter under "Office Salaries" the salaries of officers and of employees devoted to the management of the company, the preparation and collection of bills and the keeping of the company's books.

Enter under "Other Gen'l Expense" those expenses not provided for elsewhere, such as insurance (including workmen's compensation), office supplies, postage, rent of offices and garages, stationery, and the repair and maintenance of general equipment, including transportation equipment.

Water Plant

The recommended plant accounts are:

1. Organization
2. Miscellaneous intangible plant (including franchises and consents)
3. Land and land rights (including water rights)
4. Structures: springs and wells; reservoirs and standpipes; other structures (buildings and the like)
5. Pumping equipment
6. Purification system
7. Mains
8. Services
9. Meters (including installation cost)
10. Fire protection plant (hydrants)
11. Transportation equipment
12. Other general equipment

Columns have been provided for only the six plant accounts most commonly used. Additional space is available for the entry of costs in accounts other than those most commonly used. This space is marked "Other Water Plant Installed" with subheadings of "Name of Account" and "Amount." Thus, if new construction in a year involves costs applicable to several other accounts, all costs can be entered in these columns and the separate accounts summarized with ease at the end of the year.

Materials and supplies purchased for a particular construction job involving the replacement of plant which is to be retired or the installation of new plant should be entered directly in the appropriate subcolumn under "Water Plant." This includes meters, which should be entered under "Meters" when purchased even though the meter is not installed until later.

The cost of individual items of equipment of small value (for example, $10.00 or less) or of very short life, including small portable tools and equipment, should not be charged to water plant accounts. These items should be charged to the appropriate expense account when purchased.

Items costing $10.00 or more and which are retirement units in the water plant accounts (such as a hydrant, a valve or a length of pipe) should be charged to the appropriate plant account at time of purchase; except, of course, that items of a pure expense nature, no matter what the cost, should be charged to expense. (*See also* Note 3.)

Wherever "original cost" is used in these instructions, it means the cost to the person or corporation first devoting the property to public service.

Under "Organization" * enter the cost of organizing the company and putting it in readiness to do business. Do not include any expenses in connection with the issuance and sale of stocks, bonds or other evidences of indebtedness. Do not include costs of organization for any predecessor corporation.

Under "Franchises and Consents" * enter the amount actually paid to a municipality or other political subdivision for a franchise or consent, together with the actual necessary expenses incurred in securing it.

* Enter this account under "Other Water Plant Installed."

Under "Land and Land Rights" * enter the original cost of land, rights-of-way and water rights used in rendering water service to the public.

Under "Structures: Springs & Wells" * enter the original cost of structures built to develop springs and wells. Do not include the cost of springs themselves, as this should be included in "Land and Land Rights."

Under "Structures: Reservoirs & Standpipes" * enter the original cost of reservoirs, standpipes and elevated tanks, together with all appurtenances such as yard piping, control valves and automatic control apparatus. This account also includes fences protecting the land upon which these structures are located.

Under "Other Structures" * enter the original cost of other structures used in water operations, such as pumping stations, purification buildings, garages, office buildings and storehouses.

Under "Pumping Equipment" * enter the original cost of all pumps, together with the motors or engines used to drive them. This account includes the cost of all piping and valves within the pumphouse, all control apparatus used in connection with the pumps and the cost of foundations for the pump and motor, as well as all yard piping connecting pumps to mains.

Under "Purification System" * enter the original cost of all purification apparatus, such as coagulation basins, filters, clear wells and chemical treatment apparatus. Also included herein is all yard piping used in connection with the purification system.

Under "Mains," enter the original cost of all mains used in the transmission and distribution of water to customers. Yard piping used in connection with reservoirs and standpipes, pumping equipment and the purification system should not be included in this account but in the appropriate account above—for example, under "Pumping Equipment."

* Enter this account under "Other Water Plant Installed."

Under "Services," enter the original cost of materials used and labor involved in installing the service pipe and its appurtenances (usually from the main to the property line). Do not include any costs for services which were reimbursed to the company by the customer or to which title is not vested in the company.

Under "Meters," enter the original cost of all meters purchased. The cost of the first installation of a meter may be included in the cost of the meter to be retired with it, or, preferably, the cost of installing may be charged to expense when incurred. A uniform policy should be adopted on the installation costs of small meters; that is, either *all* installations should be charged to expense or *all* installations should be included as part of the cost of the meters.

In the installation of large meters, when excessive cost is involved (such as the construction of a vault or rearrangement of the customer's piping to accommodate the meter) the cost can be included in this account, but a record should be kept of the cost of installation at each location so that it can be retired when the installation is abandoned. It is suggested that the cost of installation be noted on the "Customer Record" sheet, on the line provided for the customer, in the spaces where flat-rate fixtures would be listed.

Do not include the cost of removing or resetting meters for tests or repair, as such costs properly belong under "Transmission and Distribution Expense—Labor."

Under "Hydrants," enter the original cost of hydrants, the tee on the main, the branch pipe leading from such tee to the hydrant and any valves installed on the hydrant branch.

Under "General Equipment," enter in the "Transport" subcolumn the original cost of trucks and automobiles used in water plant operations. Under "Other," enter the original cost of all other general equipment, such as office equipment, tapping machines, thawing equipment and

pipe locators. Items of small value (for example, $10.00 or less) and small portable tools easily lost or stolen should not be charged to this account but to the appropriate expense accounts when purchased.

Depreciation Reserve

Enter, in black, the amounts of plant removal labor (from the "Weekly Labor Reports") and water plant retirements; and, in red, the salvage or trade-in value on items retired when replacement items are purchased. (*See* Note 4, p. 494.)

Taxes

Under the subheading "General," enter federal, state, county, municipal and other taxing-district taxes, including withholding taxes, unemployment and social security taxes. (Exclude income, excess-profits and capital-stock taxes.)

Under the subheading "Income," enter the amounts paid for taxes on net income, excess profits, undivided profits, excess dividends and capital stock.

Notes and Accounts Payable

The amount of notes given *for other than cash* should be recorded in red in the "Notes and Accounts Payable" column and distributed to the account or accounts associated with the items for which the note was given. Payments on such notes should be recorded in black in the "Notes and Accounts Payable" column. Notes given for cash should be recorded under "Other Receipts" in the revenue summary (*see* p. 490).

At the end of the year unpaid current bills should be entered in the disbursement ledger. To do this, enter each such bill in the "Description" column; note "AP" in the "Ck. No." column; distribute the bill to the proper expense or water plant columns; and enter the amount of the bill, *in red*, in the "Notes and Accounts Payable" column. Mark such bills "Distributed" to avoid duplicate distribution when bills are paid. Later, when the bills are paid, make similar entries in the "Description" column; note the check numbers or "C" (for cash) in the "Ck. No." column; enter the amount paid in the "Total Amount" column; and, in the "Notes and Accounts Payable" column, enter the amount *in black*. At the end of the year the net difference between black and red entries in the "Notes and Accounts Payable" column will represent *the change* in notes and accounts payable during the year. A black net total at the end of the year will indicate a reduction and a red net total an increase in notes and accounts payable, as compared with the notes and accounts payable at the end of the previous year. If both notes and accounts payable are involved it will be necessary to analyze the column entries to obtain a segregation.

Interest

Enter interest paid on notes, bonds and the like.

Dividends

Enter dividends paid and (if unincorporated) withdrawals by proprietor other than salary.

Miscellaneous

Enter any payments not provided for elsewhere. (*See also* instructions covering "Deposit" on "Customer Record Page," p. 484.)

Operating Revenues Summary

At the end of each billing period (but at intervals of no longer than six months) total the "Customer Ledger—Current Billing Page" columns for the period just ended, carrying forward page totals at the bottom of the page so that the totals on the last page will be the totals for the period, and transfer these totals to the corresponding columns of the "Operating Revenues Summary." This form (Fig. 5) provides a periodic and yearly summary of billing to, payments by, and accounts receivable from, customers. The column headings on this form are

the same as those on the customer ledger form.

Proof of the mathematical accuracy of the totals of each page of the customer ledger and of the periodic totals carried from the last page of the customer ledger to the operating revenues summary may be determined by making the following checks: "Balance Due" plus "Metered Sales" plus "Unmetered Sales" plus "Sales for Public Fire Protection" plus "Other Operating Revenue" equals total billing; total billing minus "Discounts and Adjustments" minus payments during the period equals "Balance Due" at the beginning of the following billing period.

Uncollectible Operating Revenues

At the end of the year review the balances due from customers for the purpose of determining which amounts are uncollectible. Indicate these amounts by a red line around them, add them together and enter the total in the uncollectible column of the operating revenues summary in line with the last entry for the year. Do not include the amounts determined as uncollectible in the total of balance due (amounts receivable from customers) at the end of the year when that balance is carried forward in the customer ledger to the following year. Any amounts that have been written off as uncollectible and are later collected should be entered in the revenue summary as "Other Receipts." A memorandum record should be made of uncollectible accounts and followed up for payment.

Salary and Wages Summary

Each page of the "Salary and Wages Summary" (Fig. 6) provides for four employees. At the top of the form enter the employees' names, addresses and social security account numbers. Each week's payroll will require one line across the form. For each employee, enter every week the amount of his wages (before any tax deductions), the deduction for social security tax, the withholding income tax and the net pay. In the columns at the right of the form enter the totals of these four items for all employees. Thus, the monthly and quarterly totals required for old-age benefits and unemployment insurance tax reports are made available.

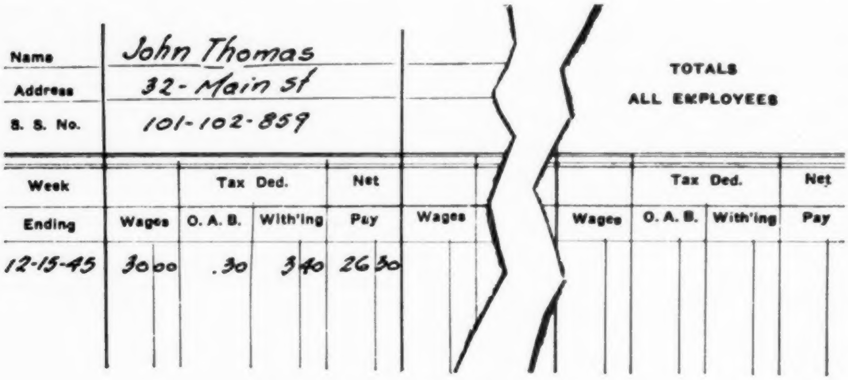

FIG. 6. Salary and Wages Summary

The disbursement ledger record of a week's payroll may be made in one entry by entering "Payroll week ended *(date)*" in the "Description" column, the total "Net Pay" amount in the "Total" column and the total "Tax Deduction" *in red* in

the "General Taxes" column; the total wages amount is distributed to the proper maintenance, operation and water plant account columns. When the quarterly old-age benefits tax payment is made, enter the entire amount in the "General Taxes" column in black, and enter the same amount, of course, in the "Total" column. By this method, the total wages are distributed to the proper accounts and the net charge to taxes is only the portion (one-half) of the tax payment to the government since the red entries in the "General Taxes" column for employee deductions offset half of the black entries therein for this tax.

When payment is made to the government for the amount of income taxes withheld, the entire amount should also be entered in black in the "General Taxes" column. However, income tax withholdings for the last quarter (or the last month if withholdings are $100 or more per month) generally are not paid until January of the following year. Thus, for red entries in the "General Taxes" column representing income tax withholdings which are not paid until the following January, there is no offsetting black entry in the year. This deficiency can be overcome by making the following entry on the last page of the disbursement ledger before making the column totals for the year:

Column	Entry
Date	December 31
Description	U. S. Treasury—income taxes withheld
Ck. No.	AP [Accounts Payable]
Total	[No entry]
General Taxes	[Enter in black the amount of income taxes withheld in the year but not paid to the government]
Notes and Accounts Payable	[Enter in red the same amount as the above black entry in "General Taxes"]

When payment to the government is made the following January (covering the balance of employees' income taxes withheld the previous year), record it in the disbursement ledger in the usual manner, entering the amount of the check in the "Total" column and the same amount in *black* in the "Notes and Accounts Payable" column.

As stated previously, the total of the column "Notes and Accounts Payable" represents *the change* therein during the year, a black total meaning a reduction and a red total meaning an increase in notes and accounts payable, as compared with the total at the end of last year.

Weekly Labor Report

The "Weekly Labor Report" (Fig. 7) is used only by employees who are engaged entirely or partly in the operation, maintenance or construction of water plant. Each such employee shall fill in each day the distribution of his time for the day and turn in the report to the office at the end of the week. Directions for the distribution of time are set forth below and also will be found on the cover of the weekly labor report container.

The office will summarize the hours in each column and multiply the hours devoted to each class of work by the hourly rate, entering such amounts in the last line of the form. The total of these amounts, entered in the space in the lower right-hand corner, will be the employee's weekly wage.

Weekly labor reports should be placed in the binder provided for that purpose and kept as a permanent record.

Oper. & Maint. Labor

Under "Water Source, Pump[ing] & Purif[ication]," enter the number of hours devoted to repairing, operating and maintaining all water plant in this category, such as dams, reservoirs, springs, wells, pumping equipment, filters and so forth.

Likewise, under "Trans[mission] & Distrib[ution]," enter the hours devoted to repairing, operating and maintaining mains, services, meters, meter installations and fire protection plant (hydrants).

Water Plant

First indicate in one of the blank columns the appropriate plant account and

WEEKLY LABOR REPORT

Name John Thomas Ticket No. 48

Week Ending Dec 15, 1945 Hourly Rate 75¢

	Oper. & Maint. Labor		Water Plant			Plant Removal Labor	Office Salaries	Totals
	Water Source Pump. & Purif.	Trans. & Distrib.	Service Lines					
Monday	8							
Tuesday	8							
Wednesday	3	5						
Thursday			4			4		
Friday	4		4					
Saturday								
Sunday								
Total Hours	23	5	8			4		40
Amount	17.25	3.75	6.00			3.00		30.00

FIG. 7. Weekly Labor Report

MATERIAL INSTALLED

	Quantity	Cost	Nature and Location of work
Mains			
Meters			
Services	1-Curb box 1-Curb stop 3/4"		New service 16 Oak St
Hydrants			
Service	30'- 3/4" cop. tube 1-3/4" corp. stop		
Total Cost	. . . .		

MATERIAL RETIRED

	Total Quantity	Items Reusable	Items Junked
Mains			
Meters			
Services	1-1/2" lead complete (30')	None	
Hydrants			

Location from which material was retired 16 Oak St

Est. Orig. Cost $15.00

Other Plant and Equipment Changes

FIG. 8. Plant Installed and Retired (Reverse Side of Weekly Labor Report)

then enter in that column all the labor time involved in new construction or plant replacement pertaining to that account.

Plant Removal Labor

Enter the labor time involved in removing retired plant and equipment.

Office Salaries

Enter the salaries of officers and employees connected with the management of the company, keeping books and preparing bills.

Plant Installed and Retired

The record of plant installed and retired on the reverse side (Fig. 8) of the weekly labor report is for the dual purpose of compiling the annual report to the Public Service Commission and the annual state special franchise tax report. It is also used for preparing the plant retirement entry for the disbursement ledger.

In the "Material Installed" and "Material Retired" spaces, record the quantity or items in each of the accounts noted. Blank spaces are provided for entries affecting other accounts. For mains, record the number of feet of pipe by size and kind. For meters, record the number, size and make; for services, record the length, size and kind of pipe, including corporation stop, curb stop and box; and for hydrants, record the make and size, the size and length of the branch, valve and box, and the size of the tee.

For simplicity of handling, in this accounting system it is recommended that new plant units and retirement units in the major accounts be recorded as follows:

1. *Mains*—each length (usually not less than 12 ft.), each valve
2. *Meters*—each meter by size, including the installation cost if desired
3. *Services*—the complete service line (company-owned portion), including corporation stop, curb stop and box
4. *Hydrants*—each hydrant, each branch line (including tee), each valve in the branch line

If the plant installed in any period at one location is less than the quantities noted above, the cost involved should be charged to expense. So also, if the units retired are less than the units recommended, no retirement entry would be involved.

In the "Material Retired" portion, a column is provided to record usable material (included in the plant retired)—that is, material sufficiently good to be reused.

The method of summarizing these reports to account for plant additions and retirement is discussed in Note 4.

It will be seen that the "Material Installed" columns provide for noting the cost of items installed. The cost data, however, need only be entered when material is taken from stock (having previously been charged to water plant) and used for a repair or maintenance job. When each such job is finished, the total cost of material used from stock, shown on these reports, should be credited to the appropriate water plant accounts in the disbursement ledger and charged to the proper expense accounts. No figure, however, should be entered in the "Total" column in the disbursement ledger when these debits and credits are entered, but an explanation should be entered in the "Description" column.

NOTES

1. *Compensation insurance.* Compensation insurance premiums when paid are to be entered in disbursement ledger column, "Other General Expense," in black. At the end of the year the portion of the premium applicable to reconstruction or new construction is to be distributed to the appropriate plant accounts, based on the hours of labor for the year (from the weekly labor sheets) that were spent

on reconstruction or new construction. The total so distributed is to be entered in red in the disbursement ledger column "Other General Expense" and black entries made in the plant account columns.

2. *Contributions in aid of construction.* Water plant contributed to the utility (water company) or constructed by it from contributions of cash or its equivalent should be charged to the water plant accounts at cost to the utility (that is, the actual cost less the portion thereof contributed by or on behalf of customers). When a contribution of labor or material is made by a customer or a federal, state or municipal body, this fact should be noted by entering the details on the weekly labor sheets.

When a contribution in cash is received from a customer or any federal, state or municipal body, the money received should be entered on the operating revenues summary sheet under "Other Receipts," with an appropriate explanation. At the end of the year the amount received is to be deducted from the balance in the water plant account to which the contribution applied. This can be done before plant retirements are entered.

3. *Disbursement ledger—materials and supplies.* In this system, no materials and supplies account is kept, but rather purchases of materials and supplies are charged directly to appropriate expense or water plant accounts at the time of purchase. For some items of material, it may be necessary to estimate a distribution of the cost between maintenance materials and supplies, and water plant accounts.

Items purely of an expense nature, no matter what the cost, are to be charged to expense. Except for service line material (which is to be charged to "Services"), items costing less than $10.00 should be charged to the proper expense account.

If an item of water plant is installed which is less than the units listed under "Plant Installed and Retired" (p. 493) the cost of the material used is to be entered *in red* in the plant account where originally charged, and in black in the appropriate expense column.

When this system is introduced, an inventory of materials and supplies on hand should be made, divided between maintenance materials and plant materials associated with each water plant account. The inventory should then be priced at undepreciated original cost and the amounts entered in the respective columns in the disbursement ledger. On the same disbursement ledger line enter in the "Misc." column *in red* the total of the subamounts of materials and supplies. Thus the balances in the water plant accounts will represent both plant in service and materials and supplies on hand, exclusive of those charged to operation and maintenance.

Items charged to water plant accounts, in accordance with the above instructions, and not immediately installed are to be entered also in a materials and supplies inventory, which should be checked annually. Retain all invoices and bills as a permanent record.

4. *Disbursement ledger—plant retirement entry.* Only one disbursement ledger entry, at the end of the year, is made for plant retired, whether removed or abandoned and left in place (except that retirements of general equipment should be entered at the time of the retirement). No week-by-week summary of plant installed and retired as recorded on the reverse of the weekly labor report is maintained, but at the end of the year such units of property should be summarized by plant accounts; also summarize the items of recovered plant material indicated as reusable. Indicate on the weekly labor sheets, at the time of sale, any sum received as salvage. To the summary lists of plant units retired, units junked and installations removed or abandoned, apply original-cost unit prices and from such totals (by plant accounts) deduct the original cost of reusable material. The remainders will be the credits to water plant accounts for

plant retired during the year. Record these amounts *in red* in the corresponding water plant account column in the disbursement ledger, put the total of such amounts in the depreciation reserve column *in black* and note in the description column: "Water plant retired during (*year*)." The sum received as salvage on items retired can be entered in total at the end of the year on the revenues summary sheet under "Other Receipts," and should be entered *in red* in the depreciation reserve column of the disbursement ledger after recording retirements as above outlined.

To record purchases of general equipment or any other item of water plant on which a trade-in allowance is received for retired equipment, enter the net cash cost in the "Total" column, the full cost in the appropriate water plant column and the amount of the trade-in allowance in red in the Depreciation Reserve column. To record the retirement of the above items, enter the full original cost *in red* in the appropriate water plant column and the same amount *in black* in the depreciation reserve column.

5. *Proof of disbursement ledger entries.* Each entry in the disbursement ledger must balance within itself—that is, the subamounts distributed in the various columns must total to the amount of the expenditure. Certain entries will include subamounts in red in some columns. These entries should balance by deducting the red subamounts from the black subamounts. Similarly, in totaling each page, the red entries in a column are to be deducted from the black entries to arrive at the net column total. The grand total of all distribution column totals at the bottom of each page should equal the "Total" column total. This check is to be made before carrying column totals forward to the top of the next page. As the disbursement ledger records only *changes* in accounts during the year, no balances are carried forward from the last page of one year to the first page of the next year.

6. *Proof of cash balance.* The cash balance may be checked at any time in the following manner: Bank balances (less outstanding checks) at beginning of year plus cash on hand at beginning of year plus revenues summary "Payments During Period" so far this year plus revenues summary "Other Receipts" so far this year minus total of disbursement ledger "Total" column equals cash balance at present.

The cash balance at present is composed of the bank balance (less outstanding checks) and cash on hand.

7. *Adjustments.* Adjustments between accounts and corrections of errors on previous pages in the disbursement ledger should be made by a new entry of the amount of the transfer or correction. In this manner, the totals of previous pages are not affected.

Cost Engineering in Water Utilities

By John C. Luthin

A paper presented on April 2, 1949, at the Arizona Section Meeting, Prescott, Ariz., by John C. Luthin, Supt., Water Dept., Santa Cruz, Calif.

COST engineering is the coordinating tie between planning, estimating, cost accounting, general accounting and cost reporting to management. It is rapidly gaining recognition as a factor in and an aid to the more exact determination and analysis of costs in businesses which are highly competitive and fluid in their operations. The need for this more positive type of coordinated control and analysis of costs on large projects became very evident during the last war. Many contractors had numerous projects under a single contract, were spending money at a high rate under rapidly changing cost conditions and were at the same time expected to maintain control of the costs. The old system employed by most contractors of accounting for cash transactions in the main office and having the superintendent on the job keep his own account of the progressive cost of the work was useless under the new order of things, with complex and unusual requirements in the methods for distributing equipment, overhead and other charges. The functions of the accountant, cost accountant and estimator required centralized control.

In the business world cost engineering is taking its place with management. It begins with the planning estimating, budgeting, and programming of work, expenditures and plant expansion. It furnishes the necessary classification of accounts to record the costs in such a form that they can be analyzed and correlated with the evolution of the program. It provides the control of cost data which reveal possible means of effecting savings in costs and improvements of methods. Finally, it produces financial data of real significance to management.

Principles of Utility Cost Engineering

The life of most industries is dependent upon accurate accounting and analysis of costs. Public utilities, although not under the pressure of competition, must nevertheless practice economies to avoid having to charge excessive rates. There is a definite practical value in cost control and savings in construction work. Utilities have a larger capital investment in proportion to revenues and profits than do most other businesses, and construction work consequently plays a large part in the operation and expansion of the plant. Municipally owned utilities are continually harassed by problems arising out of the need for new facilities. The mounting number of services which the public is requiring of its governmental bodies pyramids the cost of government and makes it increasingly difficult to promote bond issues for utility improvements. As a result, it has become

more desirable to have the utility draw up a program for its construction work and finance it out of revenues. By developing a master plan and scheduling the work and revenues required, a fixed amount can be set aside each year in a sinking fund for future construction purposes. This sum, together with the operating and maintenance costs, replacement expense and other charges, depending on the ownership, constitutes the total revenue required, and a schedule of rates to meet this demand can be established.

Cost engineering in the utility field comprises not only long-range construction cost programming but also cost analysis and control of the normal and special construction work, maintenance and operating expenses, rate schedules and reports.

Budgetary Control

The development of a water system can be compared with a large project under construction over a long period of years. It is possible, with some degree of accuracy, to forecast the development in the area served and thereby design the principal pipelines for the system and facilities to meet the ultimate needs. Such a master plan is not only useful for budgeting needs but also assists materially in selecting sizes of mains to be installed and in making provisions at intersections for future connections. This master plan should cover only those facilities whose cost is greater than can be included in the annual allowance for normal expansion—reservoir sites, dams, transmission lines, large feeder mains, treatment plants, pumping plants, tanks, wells, office buildings and other costly items generally constructed as single projects. The cost of each should be estimated and the approximate date for its need forecast. The average annual amount to be accumulated can then be determined. The construction program will not exactly fit the accumulation of funds but changes can usually be made in scheduling the work to accommodate the finances, unless costly facilities are needed at the beginning of the program. If so, and a bond issue is necessary, the annual interest and redemption charges can be substituted in the budget for the item. When possible, the annual amount to be accumulated should be charged against revenues and entered in a sinking fund for future construction, being held as cash or readily convertible investments. Privately owned utilities may prefer a memorandum schedule of the prospective amounts to be raised as a guide to management for future bond and stock issues. This construction budgeting does not begin and end with the fiscal period but is a continuing process perhaps fifty years in duration. The entire scheme must be reviewed periodically and changes in items of construction should be made to meet the needs as they develop or can be anticipated. The corresponding estimated costs and budgeting amounts should also be revised accordingly.

Construction Work

Cost engineering on construction projects begins with a study of the engineering plans to attempt to anticipate the methods of construction. The project is divided into the construction units that the contractor uses for preparing a bid sheet, and the cost is estimated for each unit. Before construction begins a classification of accounts is prepared, patterned after the bid sheet and including a description of the work to be ascribed to

each account. During construction all labor, equipment and material costs are charged to the proper account and the accounting is kept up to date on a daily or weekly basis. Periodically, during the course of construction, reports are prepared showing the actual cost of labor, material, equipment and overhead charges of the portion completed, the estimated cost of the remainder of the project and the probable total cost. All costs are analyzed by someone thoroughly familiar with the construction details and the cost accounting. Upon completion of the project a report is prepared for analysis and future reference, including not only a description of the work and methods employed but also the unit costs for each element of construction. This practice is essential in large-scale construction projects and in principle is useful for cost analysis on smaller jobs when detailed costs are desired.

Most construction work in water utility expansion and replacement involves a series of separate pipelines. The general practice is to assign a work order number to the job and accumulate the costs in the subaccount under construction work in progress, transferring the total amount to the proper plant account upon completion. This procedure is usually sufficient since some further breakdown of the labor, equipment, and materials is available from the work papers used in making labor and equipment charges and from material requisitions. If a detailed cost analysis is to be made to study differences in costs through the use of different materials and equipment, a more elaborate classification of accounts provides the only correct means of approach. For example, if detailed costs are desired on a pipeline job, a classification of accounts similar to the one below could be used:

Work Order 105—Construction of Pipeline on Main St.

105.11—Pipe
105.12—Fittings
105.13—Valves
105.14—Jointing Material
105.15—Breaking Pavement
105.16—Hand Excavation
105.17—Machine Excavation
105.18—Hauling Pipe to Job
105.19—Laying Pipe
105.20—Making Joints
105.21—Backfill (Hand)
105.22—Backfill (Machine)
105.23—Replacing Surface
105.24—Cleanup
105.25—Maintenance of Ditch
105.26—Superintendence
105.27—Overhead

A further, or only partial, breakdown may be made, depending upon the desired information. For each subaccount there should be a clear-cut description of the actual work to be included and how the charges shall be made for idle equipment and other items which require judgment in allocating. The time of labor and equipment should be kept by a timekeeper who is not otherwise associated with the job.

If only partial costs are desired, such as the cost of making the joints, and there are no other factors included, an analysis does not require a complete set of accounts and can be accomplished without a direct tie-in to the accounting.

Operating Expenses

Although many economies in maintenance and operating expenses can be effected by developing shortcuts and time-saving devices, it is, nevertheless, essential to have some means of reflecting these savings in terms of dollars and cents and to provide a basis for comparing corresponding expenses with other utilities. To accomplish these ends, it is necessary to adopt a classification of accounts in order to

separate the expenses into units of accounting significance. That system of classification should be chosen which best fits the operations of the utility, consistent with uniform accounting practices; and it should be paralleled by engineering statistics for items which lend themselves to analysis and comparison.

Reports

The financial data shown in annual reports should always be the costs as accumulated under the accounting and cost accounting systems. Small utilities often report costs computed independently of the accounting system. These costs, though accurately kept, do not include indirect charges and distribution of other costs. They are, therefore, incomplete and do not reflect a true picture.

Operating expenses should be shown by annual accounts so that comparisons may be drawn. All unusual work should be described and reasons for increases and decreases analyzed. Whenever possible, unit costs, such as costs per million gallons produced, cost per leak repaired or meter overhauled and the like, should be shown. The costs of operation should be accompanied by sufficient statistical data, shown in figures or graphically, to present a true picture of the work done and the associated expense.

Application of Principles

The water department of Santa Cruz, Calif., serves a population of 30,000, of which two thirds reside in the city, the remainder living in the fringe area. The water supply is obtained from coastal creeks and from the San Lorenzo River. The creek water, totaling approximately 2.5 mgd., is conveyed to the city system through 15 miles of transmission lines. The river water is diverted at a point inside the city and is treated and pumped into the system. The original cost of all the facilities as reflected in the books was $2,500,000, and the depreciation reserve book figure is in excess of $1,500,000. The annual income is $220,000, of which $100,000 is used for maintenance and operating expenses, exclusive of depreciation; $100,000 is required for replacements and expansion; and $20,000 goes toward redemption and interest on outstanding bonds. As a result of many years of political engineering and because of war-deferred replacements, many of the large and costly facilities need replacement in the early future.

A master plan of the system has been prepared with pipeline sizes designed for saturated development and is used as a guide in determining replacement pipe sizes. In addition, the large facilities requiring construction and replacement in the next 20 years have been listed and the costs estimated, the total being approximately $1,500,000. Concurrently a study is being made by the California Div. of Water Resources of the possible local water supplies which might be developed in the county. When the report is complete and the development to be undertaken by the city is decided upon, the work and cost program for these projects will be determined. In the meantime a study is being made of the possibility of increasing the now extremely low rates sufficiently, without overburdening the customers, to finance the construction program out of revenues.

The water department has a field crew of 25 men to do all the maintenance operation and normal construction work. Large projects are

constructed under contract. The equipment used is owned by the department and is maintained and serviced by the city garage.

A new accounting system, substantially in accordance with the procedure and classification of accounts in the *Manual of Water Works Accounting,* was installed less than two years ago. A corresponding system of work order procedures was established to provide direct control of the work done by the field men and to establish the means of making charges. The engineering, accounting, maintenance, operation, stores, management and customer billing and collecting are directly under the superintendent, who in turn reports to the city manager.

All field work begins with written instructions (accompanied by engineering drawings for construction work) on work and service order forms covering construction and retirement work, service and hydrant installation, and miscellaneous items. Emergency work orders—covering the repair of leaks, for example—may originate in the office or with the general foreman. Individual job costs are kept on construction and retirement work orders, and work on other orders is charged directly to the designated account. Time sheets are turned in daily, showing the hours worked by each man and the hours for each piece of equipment used on each work order or account. Material is obtained from stores by requisitions, indicating the work order number or account on which the material is to be used. The men's time and the materials drawn are posted daily and the cost accounting is done at the end of the month.

Stores Accounting

Stores expense, labor, salaries and equipment are handled through clearing accounts. Stores expense includes the time charged by the storekeeper (who also does meter repair and shop work) in receiving, storing and issuing material, as well as the purchase of small tools and other items which cannot be charged directly to an account or are of little cost and difficult to charge out. These expenses are distributed by adding 5 per cent to the material costs as stores expense. In order to spread the vacation, sick leave and holiday pay to the job and operating expenses, the entire payroll is debited to a clearing account. Office salaries are allocated in their actual amount to the proper accounts. The average number of actual working hours per month for field men has been estimated and their monthly salaries have been divided by this number to establish hourly rates to be used in making charges. The costs of repairs servicing, gasoline and oil and accessories for equipment are billed from the garage monthly and are debited to the clearing account for equipment. Other expenses and depreciation also are debited to this account. Hourly rates for charging the equipment to the jobs have been designed to clear out the equipment expense, including depreciation.

All stores accounting is done in the main office. The storekeeper receives copies of the purchase orders and makes out receiving reports as the material comes in, as well as requisitions for withdrawals and credit slips for returns. The accountant maintains the perpetual inventory in the office in a loose-leaf, visible-index binder. This record includes outstanding orders, receipts of material, withdrawals and balances on hand, unit costs computed by the weighted-averaged method, and minimum and maximum figures as a guide for ordering. Field checks are

made to reconcile the differences between the book and actual material on hand. The perpetual inventory, the purchase orders, receiving reports and the material requisitions are the complete stores records.

Summaries and Reports

As mentioned above, the accountant makes the distribution of expenses monthly. Since it is necessary to have the inventory record up to date, the prices are marked on the requisitions at the time the material quantities are posted. At the end of the month the requisitions are segregated by job number and accounts, and attached to an adding-machine tape showing the amount to be charged. The hours for the workmen and equipment are multiplied by their respective rates and tabulated on work sheets by job numbers and accounts. These data are then entered in a book called the cost distribution ledger which has columnar pages with headings for work order and account numbers, labor, equipment, material, stores expense, subtotal, overhead, total and four control accounts—utility plant, construction work in progress, retirement work in progress and operating expenses. The horizontal summation gives the amount to be debited to the plant and expense accounts, and the vertical summation, the total to be credited to the clearing accounts. A journal entry is made, showing the total charges to each account and subaccount, with credits to the clearing accounts and to materials and supplies. Overhead is charged at the rate of 15 per cent—which includes retirement plan costs—to all plant and construction-work-in-progress accounts, and the total is credited to the expense account for general office salaries and expenses. The latter practice is used for simplicity but is perhaps subject to criticism. From the journal the amounts are posted to the general ledger. The only remaining book is the register for listing the payroll, warrants issued in payment of materials, and other items, such as office supplies, which are purchased directly for an account. Each month the warrants are summarized in the same way as a check register and are journalized and posted to the general ledger. Before construction work orders are transferred to the plant account, the costs are broken down into labor, equipment and material, using information easily obtained from the cost distribution register. Unit costs are then computed and the data filed.

The cost accounting system outlined above is relatively simple and requires a minimum of time to operate. Control is maintained by having all original documents pass over the desk of the superintendent, who signs work orders, requisitions for purchases and time sheets. Receiving reports and requisitions for material charge-outs also pass over his desk for distribution. In this way the control is centered in one place.

Financial reports are prepared monthly to show the total of operating expenses and capital outlays for the period and a comparison with the same month of the previous year. A trial balance is prepared quarterly and the detailed expense accounts are studied for the current year and in comparison with the previous year. The annual report gives a complete summary of costs, with a general description of the content of costs by accounts, as well as explanations for unusual expenditures. The entire program has been in effect for less than two years and changes will be made from time to time as required.

Procedure for Obtaining Rate Increases

By Henry B. Steeg

A portion of a paper presented at the 1948 Indiana District Water Works Meetings by Henry B. Steeg, Cons. Engr., H. B. Steeg & Assoc., Indianapolis, Ind. Reprinted from the April 1949 issue (Vol. 8, No. 1) of The Waterspout *by permission of the Indiana State Board of Health. Although prepared for an Indiana audience, it is believed that the procedure described in this paper, and in the accompanying Discussion, has general application to water utilities throughout the United States.*

THE water works dollar, like the grocery store dollar, does not buy nearly as much cast-iron pipe, pumps and chlorine as it used to buy. Revenues may have increased, but after operating costs are paid, very little money is left to spend for proper maintenance, let alone needed expansion. And how many operators and other personnel have received salary increases even remotely approaching those granted to workers in private industry? There is only one answer: Water rates must be increased sufficiently to provide the necessary funds.

What is the procedure for obtaining a higher rate structure? In the final analysis, rates are set by the Public Service Commission of Indiana after a publicized hearing at which all interested persons are given opportunity to express their views on the question. However, a considerable amount of groundwork must be accomplished before the case reaches the commission. First of all, the necessity for an increase in water rates must be thoroughly explained and "sold" to the people back home. Without their full knowledge of the "whys" and "wherefores" of the situation, considerable opposition to the proposition will be the natural result. After all, the people are the stockholders of the plant as well as the customers, and they have every right to a complete accounting. Before that can be done, however, the facts must be ascertained, weighed and placed in proper form for presentation.

It is strongly recommended that a complete inventory of the plant and system be made. This inventory should determine what equipment has served its useful life and should be replaced now; what is the anticipated remaining life of other equipment; what additions to the distribution system are needed now; and what will be needed in the foreseeable future. Using this study as a base, there should be prepared a program of construction requiring capital expenditures and a schedule of work to be paid for from revenues. This program of construction should be realistic and based upon the assumption that costs will never return to prewar levels. It is, of course, impossible to foretell with any degree of certainty what future prices will be, but if the experience following World War I is indicative, present prices probably will stabilize at a level somewhat lower than that now prevailing.

After the program of additions and betterments has been determined, the next step will be the preparation of a

fiscal policy that will permit the carrying out of the program. Considerable study should be made of the existing rate structure and the records of individual customers in order that the equity of present rates with respect to classes of customers may be ascertained. If the existing rate schedule is found to be equitable, a percentage increase in all classes of customers will be most desirable. This method will result in the least criticism. However, since most schedules were established many year ago—sometimes without benefit of any experience records—it will probably be expedient to develop an entirely new one. With the accurate information available from operating records, it will be possible to formulate a rate schedule that will produce the required revenue and be equitable to the various classes of customers. In the preparation of a new rate schedule, it is necessary again to be realistic. In figuring the revenue to be produced, it will be better to underestimate than to overestimate. Remember that it will be much less painful to reduce rates after a few years than to request another increase.

Next comes the job of selling the program. Every effort should be made to present the facts to the greatest possible number of citizens. It is desirable to request the privilege of meeting with the service clubs, the chamber of commerce and any other organization that is interested in public affairs. Above all, the aid of newspapers should be enlisted in support of the program. A newspaper commenting favorably can be of tremendous assistance.

In the meantime the proper petitions and exhibits should be prepared and filed with the Public Service Commission. These documents will be examined by competent engineers and accountants of the commission; consequently, extreme care must be exercised in preparing the data so that no pertinent information will be omitted or presented in such manner that it may be misinterpreted. The commission is interested only in facts, and its final decision will be based on facts.

Since the docket of the Public Service Commission is extremely crowded with petitions awaiting hearing, considerable time must elapse between the date of filing the petition and the day of hearing. This time may well be spent in preparing for the hearing. The attorney for the city should prepare his presentation with as much care as the engineer. The commission is a quasijudicial body and all testimony is presented under oath. It has been the author's experience that the commission permits considerable leeway in the introduction of evidence and the testimony of witnesses so that all the details bearing upon the petition may be examined. However, the presentation should be well organized in advance so that the various phases of the case may be introduced in their logical sequence in order to expedite the hearing.

Discussion

O. M. Leonard

Chief Engr., Boyd E. Phelps, Inc., Michigan City, Ind.

A hearing before the Public Service Commission for a rate increase may be for either: [1] a general rate increase petition, requesting approval to increase the rates and charges because of increased operating costs or other conditions which have resulted from a change in operation costs or maintenance; or [2] a petition for a rate increase and approval of the sale of

revenue bonds, the increase being necessary to provide for retirement of bonds sold for the purpose of making improvements.

In general, the approval of the rate structure requires the petitioner to be prepared to demonstrate that the rates he proposes to charge are reasonable, equitable and necessary to defray the costs of operation and maintenance of the plant and system. Most of the improvements to water works systems requiring extensions and additions are financed by the sale of revenue bonds.

The authority for the issuance and sale is provided by Chapter 155 of the Acts of 1929 amended by Chapter 254 of the Acts of 1933. Under the law it is necessary to set out the proportion of the revenues needed for: [1] operation and maintenance; [2] adequate depreciation, which may include funds for extensions and additions; and [3] bond and interest redemption accounts.

Section 48–5339, Burns' Indiana Statutes makes this requirement: "*Extensions and Additions—Bonds—Certificate of Public Service Commission.* Before any bonds shall be issued as herein provided, for the purpose of providing for such extensions and additions, the said public service commission shall certify that the income and revenue of said water works, in addition to providing for operation and maintenance and depreciation, are sufficient to pay the principal and interest of said bonds that may be sold." In hearing a petition for the sale of water revenue bonds, the burden of proof rests on the petitioner's engineers.

The Public Service Commission receives the petition and the commission's engineering, audit and legal departments review it before the hearing. In general, the petition sets out the following:

1. The scope of the proposed work and the estimated construction costs (supported by bona fide bids), together with other project costs and an adequate contingency.

2. Certified copies of financial reports on the operating utility for the past three years or more, showing itemized gross earnings and expenditures.

3. The present schedule of rates and charges in effect.

4. The proposed schedule of revised rates and charges.

5. The bond ordinance, including the rate schedule and allocation of gross receipts to various funds.

6. The rate ordinance.

7. The estimate of operating costs following the construction and operation of the proposed improvements.

8. The proposed amortization schedule showing the annual gross operating revenues, allocation to the operating account, the depreciation account, the bond and interest redemption accounts and estimated surplus in the bond and interest redemption accounts.

At the hearing, the petitioner's sworn witnesses should be thoroughly prepared to testify in general as follows:

The *chief clerk or person responsible for bookkeeping in connection with water works accounts* should be able to testify that the operating record expenditures as exhibited in the petition are a true and exact copy of the accounts shown on the utility operating record.

The *superintendent or chairman of the authority operating the utility* should be ready to testify: [1] as to the necessity for the construction of the proposed improvements; [2] as to the necessity, in his opinion, for the present construction program; and, if

constructed as planned, whether or not the proposed improvements would fulfill all requirements during the life of the bonds; and [3] whether or not the estimated operating revenues and costs are a true estimate of anticipated conditions following the construction and operation of the improvements.

The petitioner's engineer should be ready to testify: [1] that he qualifies as an experienced engineer to give expert testimony; [2] that he can certify to the preparation of plans, specifications, tentative contracts and estimates of construction cost, operating expense, bond amortization and so forth; and [3] that the need for the improvements exists and that the engineering features will perform the necessary function and supply the service required.

The Public Service Commission maintains legal, engineering and audit departments, each of which has examined the petition and has rendered reports to the commission. The counsel for the commission may examine any witnesses and question them on the various phases of the petition, including all related engineering and financial matters.

The engineer should have all information available to answer these questions and, if there is opposition to the proposed improvements, the engineer may be recalled to testify and answer questions raised by those opposing the improvements.

Following testimony by the commission's audit and engineering departments, the counsel for the petitioner may wish to cross-examine the commission witnesses to clarify testimony, and the engineer should be in a position to furnish the petitioner's counsel quickly with questions or other data on which to base the cross examination.

Fred R. Witherspoon

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The interesting and timely analyses by H. B. Steeg and O. M. Leonard call rather for some supplementary observations drawn from the experiences of the Public Service Commission's engineering department than for any rebuttal of their statements. The commission would caution, however, that all water works utilities in Indiana are not necessarily in need of rate increases. A proper diagnosis of apparent operating difficulties in some isolated cases may possibly disclose inept and careless management, transfer of needed water works funds to another municipal use or failure to collect hydrant rentals and other municipal usage charges.

The point made about advising or educating the customers in advance of any improvement program or other emergency involving the increase of rates is very timely. Adequate publicity methods—including the use of local newspapers, open public meetings or questionnaires enclosed with billing statements—to inform the utility customer in advance are likely to offset prejudiced opposition and to make the informed customer friendly to the program even though his purse is affected.

The author stresses the analysis and planning in advance for any water works improvement program. This is all-important. City or town officials should be familiar with their own local needs and have a thorough understanding among themselves as to the general scope of proposed improvements, as well as their ability to finance them at charges which the traffic will bear. Competent engineering services should

be obtained to convert their general overall plans into an intelligently engineered job, including cost estimates, bid forms and detailed plans and specifications. With the present uncertain bidding practices and material-price fluctuations, it would save time to advertise and secure bids on new work proposed before attempting to estimate the total project cost and the amount of the proposed bond issue, if financing is to be done by revenue bonds. Bids may be taken subject to Public Service Commission approval of the construction and financing program.

After the total cost of the proposed improvements is established, a careful study should be made to determine the new operation and maintenance, bond and interest, and depreciation costs in future operations. Sight should not be lost of the fact that extensive additions to an existing plant are likely to increase operation and maintenance costs. This holds particularly true where water treatment processes are inaugurated. A common error in planning water works improvements is to use the bond and interest annual requirement as a pivot or starting point, and, after that need is met, to allocate what remains of annual gross revenue to operation and maintenance costs and depreciation. The better method, or the horse-before-the-cart procedure, is to anticipate accurately what the new operation and maintenance cost is likely to be; to use that and a fair allowance for depreciation as a starting point; and then to allocate what remains of anticipated revenue to the bond and interest requirement. The use of round percentages may appear to be questionable when applied to individual plants where local peculiarities exist. However, the record of some 150 municipal water utilities in Indiana—which have recently or are currently financing acquisitions and improvements by the revenue bond method—is the most accurate gage available for applying allocations of gross revenue to various accounts in working out a successful financing program. Based on that experience record in the files of the commission, it is requiring 45 per cent, or more, of gross revenue for proper operation and maintenance. In other words, if a minimum of 5 per cent of gross revenue is set aside for depreciation, a bond and interest requirement approaching 50 per cent is near the security danger zone. It is well to bear in mind also that the total funds allocated to bond and interest accounts should exceed the requirement by some 25 per cent at the end of bond tenure, or a minimum coverage of 125 per cent. An excessive allowance of gross income required for the bond and interest account should demand further consideration, either in the form of increased rates and charges or of revision and reduction in the proposed improvements.

Experience in water revenue bond financing has shown that it is important for the ordinance authorizing the bond issue to provide for the transfer of funds from one account to another. It is usually good practice to provide for such a transfer if accumulated funds in the bond and interest accounts are sufficient to meet the current year's requirement and the ensuing year's requirement, plus ten per cent in reserve. It is also highly advisable to have a callable provision in the bond ordinance for redeeming bonds in advance of maturity, if funds are available, or to finance further improvements before the end of the present bond tenure without the necessity of resorting to a less salable junior bond issue at a higher interest rate.

New Jersey Ground Water Supplies

By Thurlow C. Nelson

A paper presented on Nov. 4, 1948, at the New Jersey Section Meeting, Atlantic City, N.J., by Thurlow C. Nelson, Chairman, Div. of Water Policy and Supply, New Jersey Dept. of Conservation, Rutgers Univ., New Brunswick, N.J.

NOT many years ago the author was talking to an officer of one of the larger plastics companies in his office near Sayreville, N.J. Picking up from his desk a comb that sparkled like crystal, he remarked that foreign representatives of his firm gave to this plant adjacent to the Raritan River the distinction of making the finest cellulose acetate in the world. He laid this premium quality to the chemical nature and the low temperature of the water drawn from the shallow stratum of gravel in which the well field was located. The next few months witnessed the destruction of this priceless water-bearing horizon through salt water drawn in from the Raritan River during a period of low rainfall. The plastics company, with two others, then purchased large tracts of land adjacent to the South River, constructed a reservoir and sank a new group of wells, all at a cost of several million dollars.

With each succeeding year the outstanding importance of underground water becomes ever more apparent. Increasingly rigid standards of quality for potable water, the needs of industry for water of low temperature and of constant chemical composition, and —last but not least—the large supplies available at low cost to private development have all contributed to the increasing draft upon subsurface waters. Approximately one-third of the total water consumed in New Jersey now comes from wells. Rarely during the more than eighteen years the author has been privileged to serve as a member of the State Water Policy Commission and its successor, the Div. of Water Policy and Supply, has there been a monthly meeting in which a grant was not made for at least one new well for a potable supply. As many as four hearings on applications for new wells have been held in a single day. With the added jurisdiction over private wells given to the division in 1947, the demands have skyrocketed, though the division has been able as yet, because of inadequate personnel, to take jurisdiction in only two so-called protected areas. Urgent requests have been made to the division for some time to bring under state protection those portions of the Rahway watershed in which steadily falling well levels indicate that the draft is exceeding the recharge.

Protected Areas

It has already been stated that approximately one-third of the recorded water used in this state comes from underground. Even more striking is the fact that in metropolitan New Jersey approximately 65 per cent of the total number of individual water supply developments by municipalities

and by water companies draw their supplies from wells. This very substantial withdrawal, however, is but a part of the total. Domestic wells, though individually of little moment, in the aggregate use appreciable amounts. This has recently become a rapidly mounting item, with the growth of farm irrigation and its relatively high evaporation loss. But the great unknown in the underground water supply picture in New Jersey has been, and still is, the withdrawals by private industry.

Fortunately, however, some reasonably reliable data on the extent of these withdrawals are at last beginning to come in for two important industrial areas of the state. Chapter 375 of the laws of New Jersey, approved July 2, 1947, embraces one of the "well laws." By it, the Div. of Water Policy and Supply may, after a hearing, bring under state protection any area where the draft on ground water is so great as to threaten further development. Present users in such delineated areas are required to file statements, under oath, giving the list of wells in use on or before July 1, 1947, and their capacity. The right to continued use of these wells up to the capacity of the equipment in place on that date is affirmed by the state under this law.

Two areas in the state have thus far been established under the provisions of the law. In the first, including Middlesex and Monmouth Counties, questionnaires have been mailed to 114 industrial users of water. To date 54 replies have been received, of which 21 showed no private wells, the water being purchased from local utilities. The remaining 33 private diverters of underground water list a total of 94 wells with a total rated capacity of 44,856 gpm., or 64 mgd. The largest of these users reported 18 wells with a rated capacity of 17,400 gpm., or approximately 25 mgd. In the second protected area, which includes portions of Burlington, Camden, Gloucester and Salem Counties, 89 questionnaires have been mailed and 80 replies received. These report a total of 145 wells with a total rated capacity of 52,946 gpm., or 77 mgd.

The potential draft on underground supplies in these two protected areas already reported therefore represents considerably more than 1½ times the total capacity of the Wanaque Reservoir, the largest surface supply in the state. Whether these wells now are being pumped to capacity is of little moment to the state control body, since the 1947 law confirms to all diverters the right to use up to the full capacity of the equipment in place on July 1, 1947. Any balances resulting from present operation of any wells at less than full capacity are in reality uncashed checks issued by the state against its total assets of underground water. A real cause for concern is that periods of protracted drought may in future reduce these liquid assets considerably. In fact, it may be necessary ultimately to cash these outstanding checks on a basis of 3 or even 2 qt. to the gallon.

Recharge From Reservoirs

At Newark, experiments are being conducted in employing excess discharge over the spillways of reservoirs to restore badly depleted ground water storage levels. This work may very well be of great importance in the conservation of subsurface water supplies.

Returning recently from New Orleans by way of Chattanooga and Knoxville, Tenn., the author passed one of the major reservoirs of the TVA system. Having been stationed

in this area for some time during World War I, this trip afforded a most interesting contrast. Instead of muddy streams, eroded farms with miserable hovels and a few pathetic stalks of corn, blue-green water could be seen in reservoir and river, with a strong flow despite a drought of considerable proportions. Neat and well painted farmhouses have replaced the tumbledown shacks, and everywhere are fine, rolling fields plowed on contour. Such is the magic touch of controlled water. Might not New Jersey begin now to tame the floods of the Passaic and the Raritan through the construction of many small dams with notched spillways on tributary streams? The upper half of such reservoirs would be available at all times for flood control. The lower half, below the notch, being always filled, would raise ground water levels permanently in the vicinity. Where such ground water storage is too far from population centers to be of use directly to well fields, it could still assist indirectly by helping to maintain higher dry-weather flows in neighboring streams.

Lands so situated as to be subjected to permanent or temporary flooding could be used for a threefold purpose. In the lowest portion of the tract would be a permanent pond or lake, with its level controlled by a notched spillway. Surrounding this permanent body of water would be a somewhat larger area maintained as lawn or open woodland with picnic sites. The lawn area would provide numerous baseball and football fields, as well as concrete tennis courts. In times of flood these recreational areas would be covered with water, but there being no buildings, no harm would be done. The muddy water would drop much of its load of silt upon the lawn, assuring a continually improving topsoil for the grass. Holding back the flood waters behind the part of the dam that lies above the bottom of the notch in the spillway would lower the crest of the flood farther downstream. With a sufficient number of such flood control reservoirs, designed to discharge over the main spillway in sequence, it would be possible ultimately to obtain complete control of floods.

Subsurface aquifers could be recharged from the permanent reservoir, augmented by temporary but large infiltration from the much greater area subjected to occasional flooding. In general, New Jersey streams are in flood stage in spring before the recreational demand has set in. Should there be sudden, heavy cloudbursts during the summer, the area might be closed to recreational use for several weeks but this would be a small price to pay for protection from flood damage in cities downstream, not to mention the appreciable additions to underground water through holding part of the flood on the surface of the land for a week or more.

Those who may be disposed to dismiss this scheme as a pipe dream should turn to the Duhernal Water System on the South River for evidence of recharge of wells from a permanent reservoir. It is understood that experiments are contemplated looking toward even greater recharge of the well system through lateral channels to conduct water out on the land adjacent to the wells. The system as it stands today presents an ideal laboratory for the study of this phase of the problem.

Ground Water Use Taxes

Two problems are of rather immediate importance. Under a compre-

hensive law passed in 1907, the state has received considerable revenue from the excess-diversion tax. The possibility of obtaining further revenue through a tax on ground water is being carefully studied, because the state must have new and added sources of income. In view of the very definite relationship between ground water and stream flow, it might be in the interests of equity if diverters of subsurface water also were taxed for the use of this natural resource beyond a certain specified minimum. The somewhat difficult legal questions involved cannot be pursued further in this paper. It might, however, be well to consider the possibility of legislation based upon the excess-diversion law. Municipal and private water companies drawing from underground sources could be allowed 100 gpd. per person, according to the most recent census. For diversions in excess of this amount, payment would be made at rates from \$1.00 to \$10.00 per million gallons, as in the present excess-diversion law for surface waters. Private diverters of more than 100,000 gpd. would continue to divert up to the maximum capacity of the equipment in place on July 1, 1947, with a similar charge for diversions above this amount. Adjustment would need to be made to take care of unusual situations as in Camden, where vast quantities of well water are furnished to great industries.

Interstate Cooperation

Consideration must also be given to the need for close interstate cooperation in ground water study and control, particularly in the Delaware Valley from Camden south at least to Paulsboro. Pennsylvania has no control over private diversions from wells, but it is encouraging to learn that such legislation is contemplated. Every indication points to the probability that wells in the Philadelphia area, in the Navy Yard and on the New Jersey side across the river, all draw from the same Raritan formation, one of the richest water-bearing strata in the entire world. Evidence indicates that the principal recharge area lies in the bottom of the Delaware River between Camden and Bordentown. If this were being heavily drawn upon at present, the quality of the well water would show deterioration because of pollution in the river. It is probable, therefore, that much of the water drawn from wells in this area still comes from sources outside of the immediate region.

Static water levels in wells of the Camden area have fallen over the years, while recent tests in the new Texas Co. well field in West Deptford Township in Gloucester County have indicated drawdowns of 10–20 ft. in the Philadelphia Navy Yard at a distance of more than 6,000 ft. With the danger of salt intrusion farther down the river always at hand, it is obvious that future wise development of the ground water resources in this area must depend upon the closest cooperation among the officials of the two adjoining states. It is fortunate indeed that recent studies conducted by the U.S. Geological Survey have been made jointly by Barksdale of the New Jersey Div. of Water Policy and Supply and by Graham of the Pennsylvania Board of Water Supply.

Finally, to protect and to continue the joint research projects on ground water sponsored by the U.S. Geological Survey in cooperation with the states, constant alertness is required to see that economy moves in Washington do not curtail or abolish this essential program.

Depletion of Ground Water in New Jersey

By Henry C. Barksdale

A paper presented on Nov. 4, 1948, at the New Jersey Section Meeting, Atlantic City, N.J., by Henry C. Barksdale, Dist. Engr., Ground Water, U.S. Geological Survey, Trenton, N.J.

THE very small number of ground water hydrologists and the water works men who depend upon ground water for their source of supply have been for a long time almost the only people in this country who realized that the depletion of its ground water resources was a possibility. It is most gratifying to know that the public in general is gradually becoming aware of the problems relating to ground water depletion. This public awakening is the result of many years of patient educational work and has been greatly accelerated recently by basically sound articles in popular magazines like the recent one by Lester Velie (1).

Such articles indicate that the water supplies of large and important areas in some states are even now in a very serious predicament. Some areas in New Jersey seem likewise to be scraping the bottom of the bucket, but for the state as a whole this is not yet true, and if the conservation measures that have been adopted are wisely and courageously administered, it need never be true. It should be possible to develop New Jersey's ground water resources up to their limit, but not beyond it, so that widespread critical conditions need not develop.

Ground Water Studies

New Jersey has been, and still is, a leader among the states in the study and conservation of its ground water resources. The state geological survey has been collecting well data for more than three-quarters of a century. In 1923 the state embarked on a continuing program of quantitative ground water studies in cooperation with the U.S. Geological Survey. The state agency which has been primarily responsible for this work is the Div. of Water Policy and Supply and its predecessors. Currently the Div. of Forestry, Geology, Parks and Historic Sites of the New Jersey Dept. of Conservation is also cooperating on studies in the Newark area and the city of Rahway is cooperating on studies in its vicinity.

As the areas in which the major ground water aquifers occur and the depths at which they can be penetrated by wells in different localities were fairly well known at the outset, the new studies have principally been directed toward the assembly and analysis of data indicative of the safe yield of the aquifers, such as records of water levels and pumpage and the various factors affecting the intake, storage and transmission of water. Several progress reports (2, 3) have been issued on the ground water resources of different areas within the state. It has not yet been possible, however, to compile a report on the overall status of New Jersey's ground water resources or even to study carefully all of the important ground water areas and aquifers in the state. In this paper an attempt will be made to summarize some of the facts now known about the status of

this very important natural resource and to give a few typical examples of areas in which depletion has occurred or is threatened.

The importance of the interrelation between ground and surface water is sometimes overlooked, but it cannot be too strongly emphasized. When considering problems relating to recharge and replenishment, it is misleading to say *this* is surface water and *that* is ground water. Actually, any given particle of water may move both across the surface of the earth and through its pores at different times in the course of a single journey from the sky to the ocean. In the relatively humid climate of New Jersey, an aquifer that is not heavily pumped will usually discharge a large part of its water into surface streams in its intake area. In wet seasons it may absorb as much water as it can hold, and refuse any further recharge. The same aquifer when heavily pumped will not only absorb all the recharge that comes to it from precipitation, but will draw water from the streams that cross it.

It must be recognized, then, that the maximum possible development of New Jersey's ground water resources would result in some reduction of its stream flow. The same water cannot fill the streams and recharge the underground supply simultaneously. The reduction in stream flow would often be mitigated by the return of used ground water to the streams. However, if the ground water should be used outside the drainage basin or if, after being used, it is removed from the basin by evaporation or through sewers, the effect on stream flow may be considerable.

Safe Yield

In addition to the quantity of water available for recharge, the safe yield of an aquifer may be limited by its ability to absorb, to store or to transmit water, and by the danger of contamination. The capacity of most New Jersey aquifers to absorb water is probably adequate. In a general paper like this, it may be assumed that the works for the withdrawal of ground water will be of such a nature and so located as to minimize the limitations due to storage and transmissibility. There remains, then, only the danger of contamination —particularly by salt water—to be considered in making a broad estimate of the safe yield of all the aquifers in the state. New Jersey is bordered by salt water from somewhere near Camden down to Cape May and from there along the eastern shore to the New York state line. Various types of inlets bring salt water inland for some distance at many places. Heavy pumping anywhere along this long coastline is likely to induce an intrusion of salt water, and the safe yield in a band adjacent to the salt water is likely to be limited more by the danger of salt water intrusion than by any other factor.

It has been possible to cover only a small part of the state with the detailed and thorough quantitative studies that are necessary to estimate the safe yield. Considerable error may be involved in extending the results to the entire state, but, on the basis of present knowledge, it is estimated that the total safe yield of the important ground water aquifers in the state is on the order of 1 or 2 bil.gal. daily. This estimate is little more than an application of the data obtained in some of the area studies to the state as a whole, making allowance for unproductive areas and for those exposed to salt water intrusion.

The problem of estimating the probable ground water use within the state is also complicated by a lack of reliable data on a statewide basis. Obtaining reliable and continuous records of all

pumpage is one of the most essential and, at the same time, one of the most difficult parts of the quantitative ground water investigations. It is therefore to the interest of all well owners to maintain careful records of pumpage. There are good records of the ground water used for public supplies, but for the state as a whole there is relatively little reliable information on private and industrial ground water use. In a few localities, however, good data on such pumpage is available, and, by extending and applying these data on a statewide basis, a total ground water use of 500–750 mgd. can be estimated.

A hasty comparison of the estimated pumpage with the estimated safe yield, which is three or four times as large, would seem to indicate that the development of ground water resources might proceed without a care, but unfortunately the cream of the supply has already been used up. It is becoming increasingly difficult to locate sites where large quantities of ground water can be obtained safely along railways *and* highways *and* deep waterways *and* adjacent to an adequate supply of labor. Furthermore, the number of areas in which a few wells drilled on a few acres can yield 5 or 10 mgd. without endangering the safe yield is definitely on the decrease. The development of the remaining ground water resources must be increasingly troublesome and expensive as the more favorably located and the more productive areas are drawn upon to their full capacity.

Critical Areas

Actually, the ground water supply in a few areas in the state has already been seriously or even dangerously depleted. Generally, too, this has occurred in some of the areas most favored with other facilities, such as labor supply and transportation. No attempt will be made in this paper to discuss all such areas, but a few representative ones will be described.

The Rahway River Valley includes a number of growing residential and industrial communities. There is a possibility that some ground water may flow into the valley through the Short Hills gap, but, with that exception, all the water obtained in it is derived from precipitation within its drainage area. The valley is thus essentially a self-contained hydrologic unit. Most of the waste water is discharged into a trunk sewer which traverses much of the valley. The drainage area of the valley above Rahway is about 63 square miles. In 1947 there was a total well capacity in the valley of more than 30 mgd. In addition, approximately 9 mgd. was diverted for public water supply directly from the stream. Water was thus being withdrawn from the valley at an average rate of about 0.5 mgd. per square mile. This quantity is probably close to the safe yield of the rocks that underlie the valley. In dry seasons, when the flow of the stream is supported mainly by ground water seepage, very little water passes the lowest point of diversion.

In the Newark area, a great many wells have been drilled in close proximity to one another, and the competition for water has been keen. As the demands for water have increased, the water levels have been drawn down until, in the summer of 1947, levels as low as 240 ft. below the surface were measured in unpumped wells. A majority of these wells draw from shales and sandstones of Triassic age. Because the water-bearing openings in the rocks decrease in number and size with increased depth, there is grave danger that the safe yield has been exceeded. Furthermore, the rocks re-

ceive their recharge locally, and a substantial intrusion of salt water has occurred from the Passaic River and Newark Bay, thus rendering the water from some wells near the shore unfit for most ordinary uses except cooling. That the water levels did not fall so low in 1948 is due in part to the greater rainfall in the summer and in part to recharge operations undertaken during the winter of 1947–48.

In many other localities along the coast of New Jersey, the safe yield of aquifers or parts of them is limited by the danger of salt water intrusion. A few typical examples follow, and there are at least as many more.

At Atlantic City, the water levels in the so-called Atlantic City 800-ft. sand have been lowered about 100 ft. below the original static level, and an advance of salt water from the direction of the ocean seems likely, even without any increase in pumpage. At Cape May, the recent construction of a canal has reduced the end of the peninsula to a small island entirely surrounded by salt water. Wells drilled to depths of 600 ft. or more have always yielded water of objectionably high salt content. Two other aquifers at depths of approximately 100 and 300 ft. now yield good water, probably from local recharge. The water from the 300-ft. level, however, is steadily increasing in chloride content, and the construction of the canal has reduced materially the area in which it is safe to draw water from the shallow horizon.

In the Parlin area, the usefulness of wells that formerly yielded approximately 9 mgd. from the Farrington sand, of Cretaceous age, is threatened with complete destruction by the intrusion of salt water from ship channels a mile or two from the well field. The usefulness of these wells is being extended by holding them in reserve for emergency and peak load operations. Very careful observations are being made of the movement of the salt water, however, and there appears to be little doubt that it will ultimately reach all the pumping wells.

The five areas cited tend to show the nature and suggest the extent of the depletion of the ground water resources of New Jersey. These and others in the state might be classed in two groups. One is characterized by exhaustion of the supply, as appears to be imminent in Newark and may soon occur in the Rahway Valley, unless development there is checked. The other is a kind of deterioration in quality caused by salt water intrusion in various localities along the coast. Either type generally means that water supplies must be drawn from greater distances or from less productive sources, or both. Both of them point to the need for cautious and intelligent development of the remaining ground water resources.

Physical Measures for Conservation

There are certain constructive measures that should be taken to offset the threatened depletion of New Jersey's ground water resources. The relatively negative reaction of merely seeking other sources or other areas to develop need not be the only one. Water conservation measures may bring or hold the use of ground water within the safe yield of present sources of supply. Some good land use practices tend to increase natural recharge. Artificial recharge by water spreading or through wells has great possibilities of increasing the safe yield of some aquifers where surface water or used ground water of suitable quality is available for that purpose.

Conservation measures as applied to ground water include all the various

methods of preventing waste. Especially important among them are the water-saving devices that may be used in cooling and air-conditioning plants. Some of these processes will save as much as three-fourths of the water that would be used if it were merely pumped from the well and circulated once through the system.

Land use practices that may help to increase natural recharge, and thus increase the supply of ground water, include terracing, cover crops and other measures designed to hold water on the land and prevent rapid runoff. In general, they are practices that will benefit the farmer and conserve soil. They will be slow in achievement, however, because they must wait upon education.

Perhaps the most important and constructive measure, and the one that is often readily available, is artificial recharge, usually accomplished either by water spreading or directly through wells. The method adopted would depend upon the amount and character of water available for recharge and upon the facilities at hand for introducing it into the aquifer. Artificial recharge with untreated surface water can generally be best accomplished by water spreading. Artificial recharge through wells requires water of better quality, such as treated surface water or used but uncontaminated ground water from cooling plants.

Artificial recharge is being practiced on varying scales in several localities in New Jersey. The most notable water-spreading developments are those at the Perth Amboy water works, the Duhernal water supply—both near Old Bridge—and the East Orange water works. The most significant and largest artificial-recharge development by the use of wells is that undertaken in 1947 at Newark.

Legal Measures

In 1947 the state legislature authorized the Div. of Water Policy and Supply to regulate areas in which the safe yield of aquifers is being, or threatens to be, exceeded (*see* T. C. Nelson's paper, p. 507, *this issue*). This act has placed the state in a position to conserve most of its ground water resources and prevent their depletion. It makes no provision, however, for the recapture of existing diversion rights and is, therefore, most effective where the safe yield is being approached but has not yet been exceeded. In such areas, by granting diversion rights that may be modified or terminated after a reasonable period, the safe yield may be approached more closely and confidently than would otherwise be possible.

Summary

It may be said that, on the whole, the ground water resources of New Jersey have not been depleted, although some serious local conditions have developed. Constructive measures are being adopted to conserve and increase the supply in some localities. Much more can be done in this direction as the need becomes apparent and the means become better understood. To this end the quantitative ground water investigations are being continued and should be expanded.

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Stretching Income to Survive Inflation

By Raymond H. Fuller

A paper presented on Oct. 7, 1948, at the Ohio Section Meeting, Mansfield, Ohio, by Raymond H. Fuller, Partner, Burgess & Niple, Columbus, Ohio.

NUMEROUS factors may be considered in reviewing any particular water works operation for possible ways of reducing costs.

Labor relations. Many men in the water works profession stick to their jobs year after year at low rates of pay; but after a time low salaries and poor working conditions do have an effect, and the production per dollar spent falls off. The inducement to new personnel should be equal to that of like work in the community. Pay and working conditions should be good enough to attract able and competent men.

Tools and equipment. It is often necessary to spend money in order to save money. Good tools and equipment pay in savings in time and repair bills. An air compressor with pavement breakers and spades is frequently a money saver. Power hoists and conveyors to handle chemicals and coal save money in the form of labor and make the job more attractive.

Trade items. The periodic review and examination of materials and supplies offered by the trade is especially important in these times of scarcity of materials and changes in price. Changes in price and the development of new products sometimes make past practices and policies economically unsound. The appearance of new kinds of pipe, fittings, joints and pumps, and the changes in the cost of labor and material, may result in appreciable savings if properly analyzed and taken advantage of.

Modernization. Replacement of power and pumping equipment with new and modern equipment of the same type, or of a new kind entirely, has often resulted in an annual saving sufficient to pay for the new equipment and leave a remarkable balance as reductions in operating costs. Complete electrification has greatly decreased the power and pumping costs in many small plants. Economies in power can sometimes be realized and expansion of the plant deferred by the cleaning of transmission lines and by providing additional storage and small booster stations in some outlying sections of the community.

Industrial water sales. With the wide diversification of industries to new areas, much new use of industrial water is being experienced. Although local community spirit and interest favor industry and are anxious to serve it well, including the providing of adequate water, a sudden and large increase in industrial water usage can result in additional need for plant expansion. Sometimes the increased monetary return from industrial sales will not provide adequate revenue to justify the expansion, and the consequence will be poor service from insufficient plant capacity or the necessity for a change in the rate structure.

Delinquent accounts. In communities where good water works management practice is not established, delinquent accounts are still the source of much loss in revenue. Examination of the records of three municipalities ranging from 4,000 to 6,000 in population indicated approximately 15¢, 20¢ and 50¢ per capita per year, respectively, in delinquent water bills. It is unfair for the water customer who pays his bill to have to contribute free water to other users.

Refinancing. Occasionally refinancing of indebtedness against the water works property at lower interest rates can result in appreciable savings. Probably the best way to approach this problem is by talking it over with representatives of the local bank or bond trustees.

Unaccounted-for water. It appears to be a matter of historical fact that water works management is continually faced by two problems: to account for a reasonable percentage of the water produced and to secure an adequate revenue from the operations. Excessive unaccounted-for or nonrevenue-producing water is commonly found to be a cause of high operating costs. As water demands increase and water production costs go up, the effect of unaccounted-for water becomes more and more pronounced. Reducing unaccounted-for water has the twofold effect of decreasing the operating costs and expenses incidental to its production and putting off the day when plant expansion for increased production is necessary.

Controlling Lost Water

The control of unaccounted-for water is a continuous process, requiring constant vigilance on the part of the water plant management. In order to control unaccounted-for water, it is first necessary to know the amount of the loss, information which can be obtained only by proper metering and accurate records. It is essential that a master meter be available at the water plant, with such other meters at the source of production as are necessary to determine adequately the amount of water put into the distribution system for sale. It is just as essential that the amount of water sold be determined. Therefore, the water sales must be totaled for each collection period and the water sold compared to that produced. Under ordinary circumstances, a water system that sells 80 per cent of its production is doing an excellent job. This figure should not include hydrant, street and sewer flushing, which are normal municipal uses. When the water sold is less than 80 per cent of the water produced, it certainly behooves the good water works manager to determine the source of the loss and correct it if it is practical to do so.

An all too common cause of lost water is underground leakage, generally of two kinds. One is a leak in clay soil or other impervious formations which will immediately come to the surface and be exposed. These leaks are usually found and corrected very quickly. The other and more costly type of leak does not come to the surface but finds or develops channels to streams, sewers or other outlets where the water can flow unnoticed for long periods of time. Leaks of this nature are sometimes found in old extensions no longer used and in services which have been turned off at the outlet, instead of at the main, and have since developed leaks. Such leaks will often find their way into old basements or around filled ground near

foundations or warehouses and other large buildings. If the buildings are occupied infrequently or excessive water flows are disregarded by the attendants, leaks may go for long periods without detection.

Underregistration of meters is another important cause of unaccounted-for water. As a general rule, it pays big dividends to maintain meters. Many water losses can be calculated in dollars and cents only on the basis of water production costs—say, 2¢–6¢ a 1,000 gal. Far more costly is the loss due to underregistering of meters or unmetered services. It is generally accepted as sound business practice that all services should be metered. It must also be realized that the value of water lost through underregistration should actually be computed at the sale price of the water—say, 30¢–60¢ per 1,000 gal.—because it does go through the meter and is used for purposes for which water would otherwise be sold.

Underregistration may result from fluctuating flows, some of which are beyond the range for which the meter is capable of accurate measurement. Another cause may be lack of proper meter maintenance. The length of time to leave meters in service between tests should be determined for each system on the basis of the economy involved. The length of time a meter remains in service before testing and repair should be such that the savings from testing and repairing all meters at the determined interval of time will be greater than the annual testing and repair cost (1). A general rule cannot be established, as the condition of the water metered, the kind of meter, the water usage and the rates of flow may affect the quantity of water lost in any particular system over any particular period. It is only through a careful check of many meters in any one system that the most economical meter-testing procedure can be established. Such a study will usually establish an optimum testing interval somewhere between five and eleven years.

An actual example will illustrate the seriousness of water losses from underregistration. A certain water works pumped 103.6 mil.gal. of water in one year. Of this amount, 57 mil.gal., or 45 per cent, was not sold or was "unaccounted for." The gross revenue from water sold in this municipality averaged 60¢ per 1,000 gal. for the year. Some studies have indicated that, on the average, 30–40 per cent of the unaccounted-for water will be the result of underregistration. Assuming that half of this low figure, or 15 per cent, could be recovered through a properly operated meter-testing and repair program, 7 mil.gal. a year could be recovered by the water system in question. At 60¢ a 1,000 gal., the water would be worth $4,200, or over 12 per cent of the gross revenue for this particular water works. At the high figure of $1.00 per meter per year for testing and repair to effect this saving, the increased water sales would net the water works $2,400 a year, or more than 7 per cent of the experienced gross revenue. The $2,400, of course, would be all profit as no other increase in operating and maintenance costs would occur. This example indicates the hidden losses that can go on indefinitely when the prevailing motto is: "Don't take the meter out until it stops registering."

Other causes of unaccounted-for water which are found with varying frequency are overflows from storage tanks, excessive use of water for treatment plant operations, leaks at stream

crossings, unauthorized taps to fire connections, excessive flushing of sewers and streets, and leaks at valve stems and hydrants.

The entire water works organization should be conscious of the necessity for reducing losses and detecting sources of water waste. Meter readers, particularly, can be helpful if they are trained to watch for wastage or leaks and to develop the cooperation of the public in reporting these items. Assistance to the water department can properly be secured from the personnel of the police department and the street crews. These municipal employees, covering the entire town at all times, can be of great help in reporting leaks if they feel that such cooperation is appreciated by the water department. If the water shortage or wastage is severe, newspaper publicity or advertising campaigns, even offering small rewards for the detection of waste or leaks, can be inaugurated.

If the water works personnel are unable through their own efforts to rdeuce unaccounted-for water to an acceptable figure, it is usually economical to secure the service of a professional leak-detecting company, which will make a thorough survey of the system to determine where the unaccounted-for water is going. These surveys are very successful and management will benefit by obtaining such professional assistance whenever the department's own resources are exhausted.

Water Rates

Many water works operators find that, despite good rules of management and diligent attempts to reduce costs, they have reached or are approaching a monetary deficit in these times. The only answer then is an increase in rates.

Much information has been accumulated and presented to the water works profession to establish certain facts and provide firm estimates of future trends in water system costs. For the typical or average water works, these data indicate:

1. Maintenance and operating costs have continued to increase since 1937, with sharp rises since 1942.

2. An increase in revenue from water sales has been experienced during the same period, but generally it has not equaled the increase in operating and maintenance costs.

3. Capital improvements and normal maintenance have been deferred in this same period, resulting in a "profitless prosperity" for many water systems.

4. Water works construction costs have increased 80 to 100 per cent in the same period, and some authorities do not expect them to stabilize at more than 20 per cent below present levels. This being true, the actual dollars set aside from gross revenue must be increased by the same percentage if a like degree of development and service is to be maintained in the future.

5. By and large, to meet these increased costs adequately, water rates must be increased 25–30 per cent over the 1935–38 level.

6. The water works that has not increased rates is bleeding its capital account to meet the increased operating and maintenance costs. It is putting off the day of reckoning until major improvements are required to prevent a breakdown of service, or until net income is completely wiped out.

Table 1 shows the financial trend of ten municipalities in Ohio since 1937. It is significant that the operating ratio (operating and maintenance

costs expressed as a percentage of gross revenue) has increased in eight out of ten of these municipalities, generally by substantial percentages over the period, and that the percentage has increased in nine of them in the last five or six years. (The tenth increased rates, thereby changing the trend.) The municipalities were picked at random from communities of less than 50,000 population where knowledge of the financial records verifies their reasonable accuracy.

The proof that a great many public officials find it difficult to accept and to act on such data is indicated by the fact that up to the present few municipalities have increased water rates sufficiently to offset this trend.

It is believed conservative to state that three-fourths of the water works are facing financial difficulty or are at present on an unsound financial basis as a result of the current price situation. Rate increases will be the only means of correcting much of this deficiency. Many water works men are putting off buying new equipment and granting wage increases, or are operating an inadequate system because sufficient rate increases have not been made.

What can be done locally about an inadequate water works income? In Ohio, the city auditor or village clerk each year prepares a financial statement showing the annual gross revenue (water sales) from water works operation and the annual operating and maintenance costs. With the cooperation of the auditor or clerk, these figures can be secured for any number of years. A study of the differences between gross revenue and operating and maintenance expenses for each of these years will indicate the financial trend. If the operating and maintenance expenses are as great, or almost as great, as the gross revenue for the last two or three years, or if this difference is approaching a vanishing point, deficits will be experienced in the near future and a breakdown of function will necessarily follow unless

TABLE 1

Revenue and Expenditure, 1937–48

City	Pop. 1940	Gross Revenue—$			Op. & Maint. Cost—$			Operating Ratio *per cent*		
		1937	1942	1948	1937	1942	1948	1937	1942	1948
1	44,000	199,087	219,702	289,284	94,321	121,277	227,763	47.5	55.5	79.1
2	31,000	141,850	160,159	239,152	78,882	106,408	171,542	55.5	66.0	71.7
3	10,000	58,100	73,135	87,604	42,254	48,110	73,985	72.5	66.0	84.2
4	9,000	73,264	73,096	94,599	29,750	31,969	59,841	40.5	43.5	63.1
5	8,000	37,683	48,996	74,883	29,112	28,304	47,367	77.0	58.0	63.2
6	6,000	42,714	44,590	59,978	15,546	20,910	42,494	36.5	47.0	70.9
7	6,000	27,406	35,577	43,852	14,086	18,369	31,553	51.5	51.5	71.9
8	5,000	15,351	18,913	41,950	13,392	14,072	30,006	86.0	74.0	71.5
9	1,895	7,216	8,380	16,533	5,281	4,890	16,823	73.0	58.5	101.8
10	1,757	4,063	5,700*	9,698	2,441	5,100*	9,867	60.0	89.5*	101.7
							Average	60.0	61.0	77.9

* 1941 figures.

corrective action is taken. When this difference between gross revenue and operating and maintenance costs is less than 25–40 per cent of the gross revenue, it may be that existing debt service costs or the costs for future major construction cannot be met without an increase in rates.

It is believed that if water rate increases are needed, one of the most effective arguments that can be used as a justification at present is the increase in operating and maintenance expenses, the management's actual experience in increased cost of construction materials and the diminishing net income of the water system. Not many officials want to operate in the red or show reduced balances for their administration. Of course, further evidence that rate increases may be needed is the rise in freight rates since the late 'thirties; the general increase in labor costs, including factory and construction wages; and the higher cost of pipe, boilers, electric motors and other water works supplies and equipment (2). Another important justification for the municipal water works is the fact that it is not uncommon today for regulatory commissions to grant as much as a 25 per cent rate increase to private water utilities because of these inflated costs.

From a review of conditions influencing water system costs the one well established fact which every water works man should recognize, and—more important for the common good—should bring home to the officials and citizens of each municipality, is that the general trend of water rates is upward and conditions cannot be visualized which will cause it to be halted. Prewar prices will not return. Water rate increases must come in most municipalities.

Main Extensions

The difficulties in maintaining adequate service are further intensified by the increased demands upon the water system for main extensions. The present cost of water lines is now double the prewar cost, and the proper financing of these extensions presents a real problem for the water works manager.

A review of present-day practices employed to meet this situation indicates a wide variation between water systems, as well as considerable variation in the policies of any one system over an appreciable length of time. This lack of standardization seems to arise from the acceptance of two basic, but sometimes conflicting, premises: [1] a water works should be operated as a business venture earning its own way, with the results of good management being reflected in either better service or reduced rates; [2] a water works is an instrument of public service, owned and operated for the public benefit, including the consideration that every citizen of the political subdivision served is entitled to equal service regardless of location or proximity to an existing water line.

The first premise provides a sound basis for management to act upon and is generally well received by the water customer who foots the bill and by the public at large. However, the public will feel a deficiency in such a policy when its interests are centered upon the desirability of a service which cannot be rendered within the limitations of such a premise. The premise is purely economic in viewpoint, and under it main extensions can be financed by the water works only if the revenue from the extension will pay for the cost of the installation.

The second premise, that of public service, takes into account such factors as the public health, the favorable influence of water service on desirable residential developments and the rights of all property owners to enjoy fire protection and a public water supply.

Regardless of the premises underlying water main extension policies, it must be recognized that many times financial restrictions ultimately determine whether or not a main is extended. For this reason, in many systems the two underlying premises are often combined in varying degrees under different circumstances to produce a policy which may be only temporarily expedient.

To keep the water works on a sound financial basis, the management must, first, provide sufficient funds for operation and maintenance; second, it must provide sufficient funds for depreciation or sinking-fund requirements and to meet existing debt service; and, third, it must provide a reasonable reserve for ordinary plant expansion which can include some extensions each year if the revenue from these extensions will be sufficient to amortize their cost. These requirements call for long-term planning and are affected by changes in policy, including main extension practices.

It is this shifting of policy, particularly under municipal operation when these changes are quickly brought about, which presents one of the big problems of management. It is difficult to meet a situation in which a well established reserve—built up to provide plant betterment, plant expansion, new equipment or other needed facilities—is wiped out by an order to extend water mains into areas where the anticipated revenues will not retire the investment. The difficulty is especially aggravated if rate increases are objected to as a means of subsidizing such investments.

These and similar common practices bring about the need for well prepared model rules or policies fostered by public-spirited groups. Will such policies have to include the concept of providing main extensions which are justifiable in the opinion of the legislative bodies regardless of anticipated earnings? The question may arise whether the only stringent requirements should be that a sound financial structure for the water works be maintained and that orderly planning be accomplished so that service is not jeopardized.

It is obvious that the problem of main extensions and their financing is directly comparable to the problems discussed in the first part of this paper. Not only does a water works manager now have little if any surplus available at the end of a year for extensions and betterments, but the cost of such extensions is now double prewar costs for similar items. Without water rate increases, it is difficult to see how the water system can function properly to furnish service sufficient for existing needs, to say nothing of undertaking main extensions, particularly in a rapidly growing community.

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Preventing the Diversion of Water Revenue

By J. Raymund Hoffert

A paper presented on Oct. 22, 1948, at the Joint Meeting of the Four States and Western Pennsylvania Sections, Philadelphia, by J. Raymund Hoffert, Chief Engr., State Dept. of Health, Harrisburg, Pa.

MUNICIPALLY owned water works are managed and operated in many different ways. Sometimes they are under the control of an independent agency, such as a water commission or an authority, responsible only to the citizens themselves and to any bondholders who may be involved. Or the water works may be operated as a separate department or —perhaps more generally—as a bureau within a department of the municipality, which may manage many other municipal services, such as the construction of municipal improvements, the operation of the sewerage system and ash and garbage collection. Such a department is usually responsible only to council as a whole, although it may be under the control of a municipal "commissioner" or a councilman. The water works may also be under the control of a councilmanic committee, or again, in the smaller communities, it may be under the supervision of a single municipal employee, who may in fact be a one-man department of public works.

The revenues derived from municipal water service are likewise handled in a wide variety of ways. Under water commission control they will generally, and under an authority they must, be kept separate for the sole use of those bodies. But otherwise the water works revenues may be paid either to the water bureau or department or to the municipal treasurer. These revenues may be credited to the water works and segregated for its use or they may be diverted into the general fund of the municipality for general municipal purposes, with or without part of the money being earmarked for outstanding water works obligations. Alternatively, money may be allocated to the general use of the department or bureau within which the water works lies.

In brief, the water works may get the entire water revenue, only a part of it or none at all. In the latter event, it must depend upon an allotment in the council's annual budget, which may or may not bear a sound relation to the actual, properly determined financial needs of the water works. The amount may be only as much as the council feels it can provide in the annual budget with due regard to the taxpayers' attitude toward tax increases.

Obviously, the effect of the diversion of water works revenues to other municipal purposes will vary with the situation but, in general, it seems most desirable to avoid such diversion by proving it to be unfair and unsound. But before it can be said whether or not a diversion is justifiable or harmful to the water works, it is necessary to consider the facts of the particular situation. Must it not be admitted that

when the charge for water service exceeds its reasonable total cost—including reserves for future replacements, extensions and improvements—there is a "profit" which is in effect an additional tax by the municipality and can justifiably be used for general purposes?

The ideal arrangement—the one which would most assuredly discourage the diversion of funds—would be a charge for water works service which just covers all the costs of such service with a limited reserve for emergencies. This is essentially the principle underlying the rates allowed to an authority under Pennsylvania law. These rates would include all capital carrying charges; operating, repair and depreciation costs; a reserve for properly planned extensions, enlargements and improvements to meet future needs; and funds for emergencies and disasters.

Such a practice would be in accordance with true cost accounting and in keeping with the original plan for the collection and use of charges for specific services and fees for special purposes, such as automobile license fees and gasoline taxes for highway funds. Under this procedure, especially if the public is fully informed that the water "rent" only covers the actual cost of the service, there is much less danger of diversion of the revenues. It is true that in more recent years in some of the states there have been diversions of such funds as auto license fees, especially during the depression period. However, when the funds have been derived from fair and not excessive license charges and gasoline taxes, there has been strong and concerted resistance to such diversion unless it was in the form of a loan to be repaid to the highway fund.

Incidentally, there can be no valid objection to a *properly secured loan* from the currently unneeded reserves of a water works, highway or other fund to serve some presently urgent need in another field, any more than there can be against any other proper loan. The only thing to be guarded against, and the one which the opponents of diversion fear, is the failure to have the funds repaid.

City Council Viewpoint

Since it is always wise to fortify one's own position by examining the motives and arguments of the other side, it is well to look at the diversion of water service revenue through the municipal councilmen's eyes. Government, which originally had one purpose, now has two. Its principal aim, of course, is to govern its citizens at home and to represent and protect them in their dealings with other peoples. For this purpose it administers laws and maintains diplomatic and military establishments and collects taxes to support these activities. A secondary and more recent responsibility, which an increasing number of citizens seem to feel is its main function, is the giving of services of all kinds.

Obviously, the only sources of revenue which the government has are taxes or service charges. Since the government has the power to make the taxes sufficient to cover all of its costs, however high, their only limit is the taxing officials' idea of "what the traffic will bear" and the taxpayers' willingness to bear it. However, the officials must recognize the power of the voters' opposition to taxes. Hence, they must try to strike a reasonable balance between the costs of government (including services) and what

the taxpayers are willing to pay. They therefore look with favor upon any source of revenue which cannot be readily labeled "taxes."

To the councilmen responsible for raising funds for *all* the costs of government, including the special services, all the revenue coming into the coffers of the government is for one purpose only—the payment of the costs of government. Hence, it is all to be used where it will serve best. If the costs of ash and garbage collection are less than the amount brought in by the charges for this service, why should not the balance be used to pay for other government needs? What more natural than that "profits" from the water works should be "diverted" to help pay for some other part of the total costs of government for the year?

The danger, of course, lies in the fact that the councilmen, generally not being water works officials or engineers, often are optimistic as to the future and may see a "profit" in the water works revenues when they are really only sufficient to meet the legitimate costs of the service—or perhaps not even all of those costs, such as the amount needed for extensions and improvements.

Rate Policies

Water rates should be based upon one of two opposite policies: They can be set at a level sufficiently high to meet all the water works expenses plus an additional sum which is a true profit and which should be used for the other expenses of the government; or the water rates may be set at a level which will cover only the true costs of the service, with no diversion of funds to other purposes permitted.

In many municipalities, especially in some of the midwestern states, a large part of the costs of government is paid from the profits of such municipally owned facilities as the electric generating plant and the water works. When the basis of the charge is *fully understood* and it is really high enough to pay not only for the costs of water service but also for the general costs of government, there can be no quarrel with the plan nor complaint against diverting the true profit.

But if the second, and to the author's mind the more logical, policy is adopted of charging only for the true cost of the water works service, then, manifestly, any diversion of funds should be resisted. If not, sooner or later that service must suffer through lack of repairs, inferior operation, inadequate extensions and improvements, or lack of reserves to cover depreciation, obsolescence and emergencies.

The further one gets away from true cost accounting and a true portrayal of purposes, the greater the danger of misunderstanding, dissatisfaction and misuse of revenues. Therefore, except in those municipalities where the cost of government is openly recognized as being paid for principally by the profits from municipally owned utilities, the second method should be adopted and faithfully followed. If this is done and proper steps are taken to acquaint the water users fully with this policy, there will be greater satisfaction on the part of the users and a greater assurance to the water works of adequate and dependable funds.

Essential Measures

For this program to succeed, however, certain measures are essential. First, there must be foresightedness to plan ahead for the operation and the future development and improvement

of the water works. Obviously, this means accurate, efficient and enlightened engineering and sound economic appraisal and forecasting.

Next, there must be fairness—fairness in estimating the costs of construction, operation, depreciation and future needs—in setting up the charges for water service. The rates should include some reserve for emergencies proportionate to their probability of occurrence, but when a reasonable reserve has been accumulated, this item should not be continued in the rate. A *real* profit must be honestly and continually eschewed.

Then there must be forthrightness. The water users must be told not only frequently and tactfully, but effectively, about the policies of the water works management. It should be made plain to them that the rates are determined in such a way as to provide only for the actual costs of water service, that they do not include a profit and that any diversion can only result in present or future impairment of the service.

And, lastly, there must be fearlessness to fight boldly against any diversion of revenues. If the water rates have been honestly established upon a nonprofit basis, supported by the data necessary to a sound determination of the engineering and economic requirements, and the water users have been acquainted with these facts through a wise public relations program in the past, it will be difficult indeed for a governing body to succeed in diverting the water works funds. If diversion is threatened, carrying the case to the water users will in all probability end the danger.

Admittedly, this proposal runs counter to the established practice in many a municipally owned water works, but the author believes that in the long run it will return greater benefits and provide more satisfaction than any other procedure.

New Indicator for Carbonate Alkalinity

By Michael Taras

A contribution to the Journal by Michael Taras, Sr. San. Chemist, Dept. of Water Supply, Detroit.

FOUR indicators of the disazostilbeneaminedisulfonate series have recently been suggested for the bicarbonate or total alkalinity determination (1, 2). Another dye of this series has been prepared which is suitable for the determination of carbonate or so-called phenolphthalein alkalinity. Like some other members of this indicator series, this compound changes from a pink to a blue, justifying its use in titrations where the colorless endpoint of phenolphthalein is obscure and even invisible.

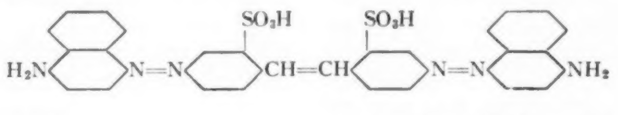
Although the monochromatic change of phenolphthalein closely approaches perfection under ideal conditions, occasions arise when individuals experience difficulty in detecting the slowly developing endpoint of the carbonate alkalinity determination. Such individuals are, however, able to distinguish a light-to-dark color transformation.

The indicator, disodium 4,4′-bis(4-amino-1-naphthylazo)-2,2′-stilbenedisulfonate, has been found to provide the necessary striking transition. The principal color change is operative in the same pH range (about 8.2) as phenolphthalein, enabling the new dye to be substituted for the more familiar indicator. The sole precaution to be observed in its application is the prior dechlorination of the sample with a drop of 0.1 N sodium thiosulfate.

In addition to the carbonate alkalinity titration, the indicator has been found to give comparable results with phenolphthalein in the determination of hydroxide and carbonate ion by the standard procedure.

Indicator Characteristics

Schultz (3) confers the formula:



on the dyestuff formed by coupling α-naphthylamine with tetra-azotized 4,4′-diaminostilbene-2,2′-disulfonic acid. In the color trade, the dye is recognized as Hessian Bordeaux.

The dye is prepared by tetra-azotizing 9.25 g. (0.025 M) 4,4′-diaminostilbene-2,2′-disulfonic acid, Eastman Kodak T4613, with 8.9 g. (0.06 M) α-naphthylamine, Eastman Kodak 172, in 100 ml. of 50 per cent acetic acid solution. The use of half-strength acetic acid must be emphasized since it is essential to the production of a superior indicator. The recommended procedure is first to dissolve the amine in 50 ml. of glacial acetic acid and then dilute the solution, with stirring, to 100 ml.

After the acid dye has been filtered by suction, it is advisable to transfer the dye from the filter paper and wash it three or four times with 95 per cent ethyl alcohol or distilled water. This operation removes practically all trace of acetic acid.

Since the indicator shows a remarkable tendency to hydrolyze in aqueous solution, an acetone solution must be prepared, which is stable indefinitely.

With these exceptions, the preparation remains the same as described in previous papers (1, 2).

The pH range of the indicator was ascertained in the sodium hydroxide–boric acid buffers of Clark and Lubs (4). Ten drops of 0.1 per cent indicator solution were added to 100 ml. of buffer solution and the resulting colors viewed in Nessler tubes. The alkaline color of the indicator is pink. The first change to mauve occurs at a pH of 8.2. All alkalinity titrations were conducted to this pronounced mauve shade. The mauve rapidly deepens to purple at a pH of 8.0 and then to the final bluish hue at a pH of 7.6.

Like the other indicators of the stilbene series, this dye is insoluble in the transition and acid range, rendering the indicator unserviceable for the colorimetric determination of pH over any extended period of time. However, the gradual insolubility serves as an advantageous warning of the imminence and presence of the endpoint.

Experimental Details

Three sets of standard solutions were used in this investigation: 0.02 *N* sulfuric acid and 0.02 *N* hydrochloric acid; 0.01 *N* sodium carbonate and 0.01 *N* sodium hydroxide; and a color solution adjusted so that 1 ml. diluted to 101 ml. would yield 70 ppm. of color. The method of preparing and standardizing these solutions and of titrating the alkalinity content has been presented in previous papers (1, 2).

The determination of the hydroxide and carbonate ion was carried out in accordance with *Standard Methods* (5). The strontium chloride method of determining hydroxide ion was used because of the superior accuracy possible with it. A 100-ml. sample was treated with sufficient 0.45 per cent strontium chloride to react with all of the carbonate ion present, and then 4 ml. excess was added. The stoppered flask was boiled two to three seconds, cooled and titrated with standard 0.02 *N* acid to the mauve endpoint of the new indicator and the colorless endpoint of phenolphthalein.

Carbonate ion was determined by the barium chloride method, a slight excess of 10 per cent barium chloride being added to the sample and the titration carried out with 0.02 *N* hydrochloric acid to the same endpoints as above.

Ten drops of a 0.1 per cent solution of the new indicator sufficed for every 100-ml. sample taken, whether color was present or absent. Titrations were performed in an Erlenmeyer flask and in a casserole.

The synthetic solutions represented in Table 2 (*see* p. 530) were prepared by mixing the required 0.01 *N* solutions of sodium hydroxide and sodium carbonate and diluting to 100 ml. with carbon dioxide–free distilled water.

Colored solutions were prepared by the addition of 1 ml. of standard color solution to 100 ml. of the above synthetic solutions. A total color of 70 ppm. was present in each sample before analysis. Titration was conducted to

the first color change of the indicator, usually a transition from reddish-orange to dirty green. Each of the softened natural waters was similarly treated with color solution in order to study the effect of the indicator on a colored natural water.

The treated waters used in these experiments were obtained from two different softening plants. Ann Arbor raw water is softened by a lime-soda split treatment, a substantial reduction in magnesium, as well as calcium, hardness being effected. The surface water which constitutes the source of Flat Rock influent is lime-softened, primarily for calcium hardness reduction.

For purposes of comparison, parallel titrations were performed with phenolphthalein indicator; and to avoid an appearance of fictitious accuracy, all final values were rounded off into whole numbers.

Effect of Chlorine

The unusual unsaturation of the disazostilbene molecule makes this series of indicators susceptible to chlorine reaction. In the presence of acid, the chlorine combines with the dye, vitiating the indicator properties of the compound. To obviate this tendency, one drop of 0.1 *N* sodium thiosulfate must be added to the sample before titration. No significant error is introduced by the step. The quantitative buffer effect of thiosulfate was determined by adding one drop of 0.1 *N* sodium thiosulfate to 100 ml. of distilled water and comparing the resultant pH with that of untreated distilled water. In both tests, the pH, determined with a Coleman Model 3D pH Electrometer, was the same—5.8. A similar coincidence was noted in solutions to which one drop of 0.1 *N* sodium thiosulfate and one drop of 0.02 *N* sulfuric acid were added. The solution containing one drop of 0.1 *N* sodium thiosulfate plus one drop of 0.02 *N* sulfuric acid gave the same reading, 5.3, as the solution containing one drop of 0.02 *N* sulfuric acid alone. Since one drop of 0.1 *N* sodium thiosulfate is equivalent to 1.8 ppm. of chlorine, dechlorination with this reagent is justified for most water supplies.

Each of the softened natural waters was dechlorinated with one drop of 0.1 *N* sodium thiosulfate prior to titration with the new indicator. No sodium thiosulfate was added to the sample taken for analysis with phenolphthalein. The uniformly close agreement between the samples containing one drop of thiosulfate (new indicator) and samples from which thiosulfate was omitted (phenolphthalein) further attests to the feasibility of adding small amounts of sodium thiosulfate without impairing the results.

Neutralization Titrations

Coupled with the preceding applications, the indicator may be employed for the typical neutralization titration, in which an acid is titrated with standard alkali. In this event, the indicator color change is reversed and the titration is carried from the blue to pink.

The four common laboratory acids (sulfuric, hydrochloric, nitric and acetic) in 0.1 *N* concentration were found to yield values comparable to phenolphthalein when titrated with sodium hydroxide of corresponding strength. In performing this particular titration, however, the determination should be started immediately upon the addition of the indicator to the acid solution,

TABLE 1

Titration of 100-ml. Synthetic Sodium Carbonate Solutions *

Carbonate Alkalinity Added	Carbonate Alkalinity Found With:		Carbonate Ion Found With:		1-ml. Color Solution and New Indicator Present	
	Phenolphthalein	New Indicator	Phenolphthalein	New Indicator	Alkalinity	Carbonate Ion
ppm.						
5	5	5	1	1	5	1
10	10	10	2	2	10	2
25	25	25	7	7	25	7
50	49	50	16	15	50	15
100	100	100	31	30	100	30
250	252	252	74	74	253	74
500	501	502	150	151	503	151

* All values represent the average of five determinations. Alkalinity results are expressed as calcium carbonate.

TABLE 2

Titration of 100-ml. Mixed Synthetic Sodium Hydroxide–Sodium Carbonate Solutions *

Hydroxyl Ion Found With:		Carbonate Ion Found With:		1-ml. Color Solution and New Indicator Present	
Phenolphthalein	New Indicator	Phenolphthalein	New Indicator	Hydroxide Ion	Carbonate Ion
ppm.					
7	8	7	7	7	7
15	15	15	14	15	15
30	31	30	30	31	30
75	76	75	76	76	75

* All values represent the average of five determinations.

TABLE 3

Titration of 100-ml. Samples of Treated Natural Waters *

Water	Carbonate Alkalinity Found With:		Hydroxyl Ion Found With:		Carbonate Ion Found With:		1-ml. Color Solution and New Indicator Present		
	Phenolphthalein	New Indicator	Phenolphthalein	New Indicator	Phenolphthalein	New Indicator	Alkalinity	Hydroxyl Ion	Carbonate Ion
	ppm.								
Ann Arbor Treated	26	26	3	3	6	6	26	3	6
Ann Arbor Filtered	14	14	2	2	4	4	14	2	4
Flat Rock Treated	28	28	3	3	6	6	28	3	6
Flat Rock Filtered	26	26	3	3	6	6	26	3	6
Flat Rock Tap	7	7	1	1	2	2	7	1	2

* Alkalinity results expressed as calcium carbonate.

because the indicator precipitates out and presents difficulties of solubilizing if allowed to stand for a time in an acidic medium.

Discussion

The data in Table 1 show that the indicator may be used effectively in the routine titration of the carbonate alkalinity of synthetic sodium carbonate solutions. Table 2 reveals that the indicator may also be employed for the quantitative differentiation of hydroxide and carbonate ions present in synthetic solutions of these constituents. Table 3 discloses that the indicator is adaptable to the standard determination of carbonate alkalinity and hydroxide and carbonate ions which are found in a softened natural water.

The indicator yields virtually the same results as phenolphthalein in each of the above instances. Furthermore, the indicator is acceptable for titrations in which the colorless endpoint of phenolphthalein is masked by color.

The indicator is also useful in normal acid-base neutralizations in place of phenolphthalein.

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Erratum

In the paper "Maintenance of Electrical Equipment" by W. J. Seibert, which appeared in the March 1949 Journal (Vol. 41, p. 240), the second sentence of the third paragraph of column two contains an error. This sentence, which now reads:

> The motor should then be reassembled, taking care to see that the end bells line up and that the current between the rotor and stator is correct.

should have read:

> The motor should then be reassembled, taking care to see that the end bells line up and that the *clearance* between the rotor and stator is correct.

The Design of Pressure Tanks for Small Water Systems

By J. A. Salvato Jr.

A contribution to the Journal by J. A. Salvato Jr., Dist. San. Engr., New York State Health Dept., Poughkeepsie, N.Y.

THE hydraulics of hydropneumatic installations was discussed recently in considerable detail by Oscar G. Goldman (1). Pressure tanks for the storage and distribution of water are particularly applicable to small water systems at developments, country clubs, camps, private estates and similar establishments where little fire protection may be desired. Pressure tank water systems have also been designed to serve relatively large communities.

Private dwellings with individual water supplies usually have hydropneumatic systems. The Federal Housing Administration (2) requires in New York State "a pressure tank containing approximately 42 gal. per living unit." The Michigan Dept. of Health (3) suggests, as an approximate rule for the selection of pressure tank sizes for small systems, that the tank have a volume "30 times the pump capacity in gallons per minute." Such a basis must first assure that the source has a yield sufficient to supply the pump selected and meet the water demand. As is apparent, these bases for pressure tank sizes have limited application.

There is need for a quick and simple method of determining the minimum size of water storage pressure tank and pump to provide for a small water system in which the maximum daily consumption does not exceed approximately 50,000 gal. Such a method is developed in this paper.

Theory

Assume that a pressure tank has a total volume equal to Q gallons. The air pressure and volume in the tank, when the temperature is held constant, will follow Boyle's well known law: pv equals a constant. With variation in the absolute pressure from p_1 to p_2 the air volume will vary from v_1 to v_2; hence:

$$p_1v_1 = p_2v_2 \quad \text{(1)}$$

When the pressure tank is just empty, its volume is equal to v_1 and the pressure to p_1; then:

$$Q = v_1 \quad \text{(2)}$$

The water available between p_1 and p_2 is $(Q - v_2)$. This volume is usually made equal to ten or fifteen minutes' storage at the maximum hourly demand and will be called Q_m. Therefore:

$$Q_m = Q - v_2$$

or:

$$v_2 = Q - Q_m \quad \text{(3)}$$

Using the data developed by Goldman, Q_m is equal to the storage at the

maximum hourly demand rate, assuming that all the water for a day is used in twelve hours. The maximum hourly rate equals 2.0 times the maximum daily rate, and the maximum daily rate equals 1.5 times the average maximum monthly rate. (For example, if the average maximum monthly water consumption is 60,000 gal., this would correspond to 2,000 gpd., or, if all the water is used within twelve hours, the maximum daily rate would be $1.5 \times 2{,}000 \times \frac{24}{12} = 6{,}000$ gpd. The maximum hourly rate would then be $2 \times 6{,}000 = 12{,}000$ gpd., or 8.33 gpm. The fifteen-minute storage, Q_m, would be $8.33 \times 15 = 125$ gal.)

Substituting Eq. 2 and 3 in Eq. 1:

$$p_1 Q = p_2(Q - Q_m)$$

$$Q = \frac{Q_m}{1 - \dfrac{p_1}{p_2}} \qquad (4)$$

Application

It is therefore possible to compute directly the required volume of a pressure storage tank by substituting in Eq. 4. For practical purposes, p_1 (absolute) can be taken as equal to the required minimum gage pressure at the storage tank in pounds per square inch, plus atmospheric pressure, needed to operate satisfactorily the highest fixture. Atmospheric pressure may be taken as 14.7 psi. and the pressure at the highest fixture as 15 psi. Of course, all head losses that are significant must also be taken into consideration. The value of p_2 (absolute) is usually between 10 and 20 psi. greater than p_1, with the smaller variation being recommended. Since Eq. 4 is based on an empty pressure storage tank, the inlet and outlet pipelines should enter and leave at the bottom. If the water lines enter and leave the tank from the ends or sides, above the bottom, then a minimum water seal is required at all times above these lines and the required pressure tank volume should be computed above this level.

The size of the pump required can be taken at 120–125 per cent of the maximum hourly demand rate in gallons per minute.

Figure 1 has been prepared from Eq. 4 to simplify and expedite the calculations to obtain the required pressure tank and pump size. It is based upon the provision of fifteen minutes' storage at the maximum hourly demand rate and a pump capacity of 125 per cent of this rate in gallons per minute computed as explained above.

For example, say that the maximum water consumption, based on the maximum monthly rate, is equal to 6,000 gpd. The required minimum gage pressure is 40 psi., and the maximum gage pressure is taken as 50 psi. The ratio of p_1 to p_2 absolute is:

$$\frac{p_1}{p_2} = \frac{40 + 14.7}{50 + 14.7} = 0.85$$

Find 6,500 gpd. on Fig. 1 and move horizontally to the right to the curve $\frac{p_1}{p_2} = 0.85$ and then down to the pressure tank volume, 2,710 gal. A 3,000-gal. tank should therefore be used. To find the required pump size, move horizontally from 6,500 gal. to the pump capacity curve and then up to 34 gpm. A 35- or 40-gpm. pump should be used, depending upon what is available.

If only ten minutes' storage is desired, take two-thirds of the pressure

tank volume indicated by the curve. The curve can be adapted for greater daily water consumptions. For example, if the average maximum daily water consumption is 50,000 gal. and

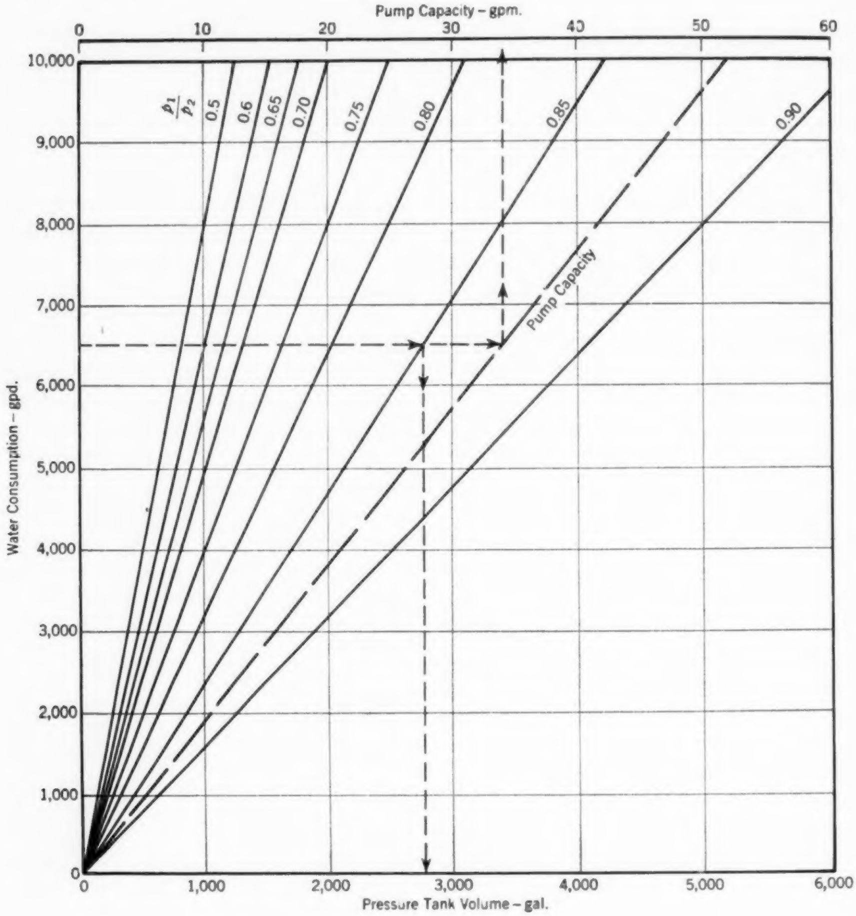

Fig. 1. Tank and Pump Sizes

$\frac{p_1}{p_2}$ is equal to 0.80, the minimum pressure tank volume required is 15,600 gal. and the pump capacity is 260 gpm.

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Discussion

Oscar G. Goldman

Supt., Water Dept., San Francisco.

The author's paper is a worthy contribution, further stressing the necessity of good design in hydropneumatic installations. Experience shows that the development of this type of installation for domestic water distribution has been sadly neglected. This neglect is largely due to a misunderstanding of the design fundamentals, with a resultant failure of the tank to perform when installed. It should be stressed that the size or volume of the tank is of no value in itself. The usefulness of the tank depends on *the ratio of the volume of air to the volume of water which can be removed for any predetermined pressure drop.*

The author's Eq. 4 is very useful and easily applied. It should be emphasized, however, that the equation assumes an empty tank at the *minimum* pressure condition. In this type of installation it is extremely important that provision be made for a *water seal.* Without an adequate water seal, the variations in air temperature which occur present a real danger of air getting into the distribution system. A properly installed control should also be provided to relieve the excess air due to expansion caused by a rising temperature. Likewise, the finished installation should include means for supplying air to the tank when the temperature falls.

Attention is also directed to the fact that the curves proposed by the author

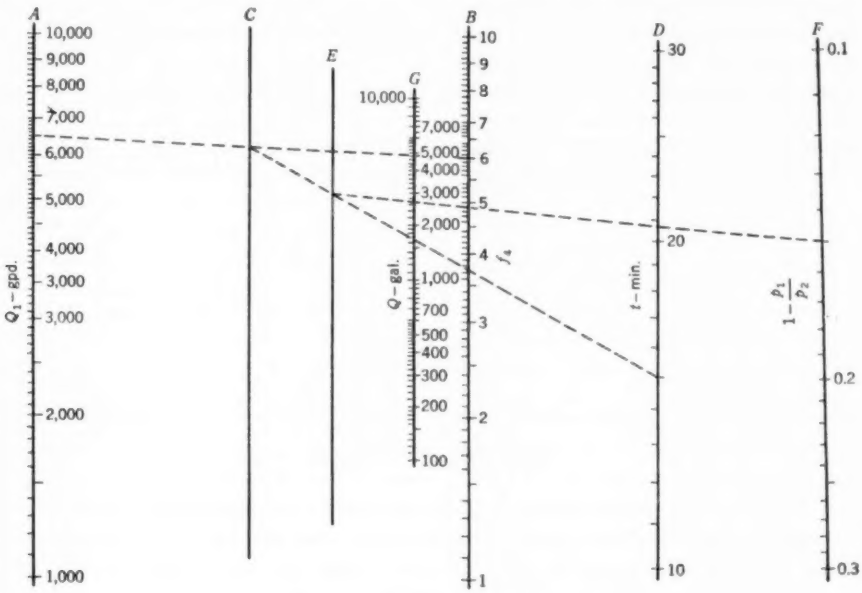

Fig. 2. Nomograph for Eq. 5

are for particular conditions of demand and use, which will differ from place to place. The relationship between the average monthly use and the maximum hourly demand should be determined for each locality in question. To do otherwise might cause so great an error that the design of the tank and pump would be a failure.

Instead of a set of curves which might be developed for each special instance, the writer would suggest a generalized nomographic curve applicable to any set of conditions. Let f_1 equal the ratio of hours per day to hours of use; f_2 equal the ratio of maximum daily use to average daily use based on maximum monthly use; f_3 equal the ratio of maximum hourly use to maximum daily use; f_4 equal $f_1f_2f_3$; t equal the duration of storage; Q_1 equal the average daily use based on the maximum month; and T equal the number of minutes per day, a constant. Then, based on the author's Eq. 4:

$$Q = \frac{Q_1 f_4 t}{T\left(1 - \frac{p_1}{p_2}\right)} \quad \ldots\ldots(5)$$

in which:

$$Q_1 f_4 \frac{t}{T} = Q_m$$

The nomograph in Fig. 2 is for the solution of any problem based on Eq. 5.

This Month's Cover

The penholder pictured on the cover has by now been converted into a gavelgrasper and the theatre of operations from Florida to all America, but the actuator involved is the same A. P. Black who has devoted a couple of decades of interest to A.W.W.A. affairs and has now taken over their direction. For a more formal view of your new chief, see the portrait facing text page 479; for a story of his accomplishments, see page 1 of P&R.

Bactericidal Effect of Chlorine Dioxide

By G. M. Ridenour and E. H. Armbruster

A contribution to the Journal by G. M. Ridenour, Assoc. Prof., Dept. of Public Health Eng., and E. H. Armbruster, Research Assoc.; both of School of Public Health, Univ. of Michigan, Ann Arbor, Mich.

SOME of the bactericidal properties of chlorine dioxide have been given in a previous report (1), in which the effect of the gas on *Escherichia coli* was investigated in artificial and natural waters and sewages. Other organisms in natural river pollution were also studied. The conditions of the study were limited, however, with respect to the temperature and pH factor as well as specific types of organisms other than *Esch. coli.*

Additional studies have now been completed to include further investigations on the common water pathogens, *Eberthella typhosa* (Hopkins), *Shigella dysenteriae* and *Salmonella paratyphi B;* two organisms of relative resistance to disinfection, *Pseudomonas aeruginosa* and *Staphylococcus aureus;* and the sanitary test organisms, *Esch. coli* and *Aerobacter aerogenes.* The effect of chlorine dioxide was also related to chlorine as a base line. It is thought that these seven organisms should, because of type representation, offer rather complete information on the possible bactericidal effectiveness of chlorine dioxide in water disinfection treatment.

The data obtained in the studies to be described indicate that chlorine dioxide: [1] is bactericidal to the common water pathogens; [2] requires approximately the same practical residuals as chlorine to secure disinfection; [3] increases in efficiency with increase in pH, making it very suitable for a high-pH or lime-softened water; and [4] destroys common water pathogens at the same or slightly lesser residuals than are required for *Esch. coli,* thus allowing the use of the same sanitary test organisms as for chlorine.

Method of Study

Preparation of chlorine and chlorine dioxide demand-free water. In studying the bactericidal effects of low dosages of chlorine or chlorine dioxide, it was essential to work with a test water that was chlorine or chlorine dioxide demand-free. Ammonia and organic matter were removed as completely as possible. To effect the removal of chlorine- or chlorine dioxide–consuming compounds in the water used in these investigations, 5-gal. carboys of distilled water were chlorinated to a 5–10-ppm. residual and allowed to stand for 48 hours. Five-liter portions of water were then drawn off into 6-liter flasks and dechlorinated with sodium sulfite to 0.02–0.04-ppm. residuals. The remainder of the chlorine was removed by vigorous boiling for 20 minutes. After cooling, if the water gave no color with ortho-tolidine and demonstrated no demand over 0.015 ppm. for either gas, it was considered acceptable and stored, usually overnight, for testing purposes. Chlorine demand control checks were also run on this same dilution water at frequent

TABLE 1—*Average Per Cent Kill of* Eberthella typhosa

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7.0			Chlorine pH 7.0			Chlorine Dioxide pH 9.5			Dilution Water Demand Control—*ppm.*			
										Chlorine		Chlorine Dioxide	
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual	OTA Residual	OT Residual	OTA Residual
20°C.													
0.01	trace	trace	84.6	—	—	56.9	trace	trace	95.0	0.005	0.005	0.005	0.005
0.02	0.010	0.005	99.8	0.01	trace	92.4	0.005	trace	99.9	0.015	0.015	0.015	0.015
0.03	0.015	0.015	99.9	0.015	0.005	99.6	0.010	0.005	99.9	0.030	0.025	0.025	0.025
0.04	0.025	0.025	100.0	0.025	0.010	99.7	0.020	0.015	99.9	0.040	0.035	0.035	0.035
0.05	0.040	0.035	100.0	0.035	0.015	99.8	0.025	0.025	100.0	0.050	0.045	0.045	0.045
0.075	0.065	0.060	100.0	0.06	0.02	100	0.050	0.040	100.0	0.075	0.070	0.070	0.070
5°C.													
0.01	trace	trace	75.5				trace	trace					
0.02	0.010	0.010	92.8				0.010	0.005	93.0				
0.03	0.020	0.015	99.4				0.020	0.015	99.9				
0.04	0.030	0.025	99.5				0.025	0.020	100.0				
0.05	0.040	0.035	99.8				0.035	0.030					
0.075	0.065	0.060	100				0.060	0.055					

TABLE 2—*Average Per Cent Kill of* Escherichia coli

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7.0			Chlorine pH 7.0			Chlorine Dioxide pH 9.5		
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*
20°C.									
0.01	0	0	94.38	0	0	11.1	trace	0	4.7
0.02	0.01	0.01	96.67	0.01	trace	86.43	0.01	<0.01	99.467
0.03	0.02	0.015	97.50	0.02	<0.01	99.978	0.02	0.01	100
0.04	0.028	0.025	99.667	0.03	0.015	99.994	0.03	0.025	
0.05	0.04	0.03	99.9314	0.05	0.019	100	0.04	0.038	
0.075	0.06	0.06	99.99	0.075	0.03		0.06	0.05	
0.10	0.095	0.085	100	0.11	0.04		0.08	0.070	
0.15	0.130	0.120		0.17	0.125		0.125	0.12	
5°C.									
0.01	0	0	70.6				<0.01	trace	92.43
0.02	0.01	0.01	76.5				0.015	<0.01	
0.03	0.019	0.015	84.7				0.02	0.018	
0.04	0.025	0.025	91.76				0.028	0.022	99.979
0.05	0.035	0.035	96.49				0.032	0.03	100
0.075	0.06	0.06	99.624				0.06	0.06	
0.10	0.085	0.08	99.9647				0.085	0.07	
0.15	0.125	0.12	100				0.13	0.11	

intervals during the bacteriological testing. These checks consisted of comparing chlorine residuals on the dilution water to the weights of chlorine applied.

The pH of this test water was adjusted by the addition of 150 ppm. of phosphate buffer to secure a pH of 7 and 150 ppm. of carbonate buffer for a pH of 9.5.

Preparation of stock solutions. The chlorine dioxide stock solution was prepared by the addition of HCl to $NaClO_2$. The gas evolved was drawn off by vacuum and dissolved in the chlorine and chlorine dioxide demand-free distilled water. The chlorine stock solution was prepared in a similar manner, using HCl and NaOCl. Both stock solutions were stored in the refrigerator in amber bottles for use in making the daily working solutions. Never did the length of storage exceed 30 days, and before use the purity and relative strength of each solution was tested. Immediately prior to bacteriological testing, working solutions were prepared at a concentration of 20 ppm. as measured by ortho-tolidine.

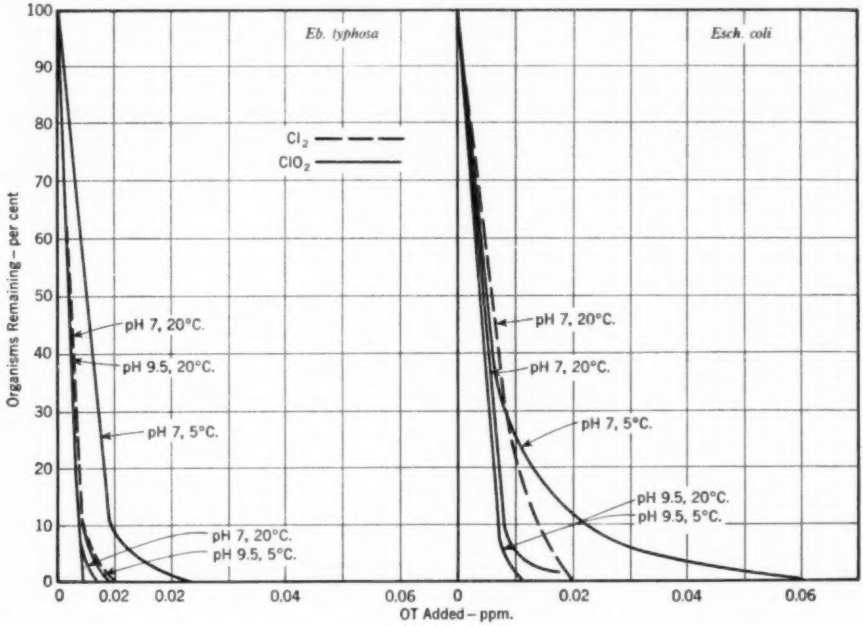

FIG. 1. Bactericidal Effect of Chlorine Dioxide
(*Eb. typhosa* and *Esch. coli*)

Test organisms and preparation. Test organisms used in this study were *Esch. coli, Aer. aerogenes, Eberthella typhosa* (Hopkins), *Shigella dysenteriae, Salmonella paratyphi B, Pseudomonas aeruginosa and Staphylococcus aureus* (209). All organisms were carried by daily transfer in F.D.A. nutrient broth. In preparing suspensions of these organisms, nutrient agar slants were seeded from a 24-hour

TABLE 3—*Average Per Cent Kill of* Shigella dysenteriae

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7.0			Chlorine pH 7.0			Chlorine Dioxide pH 9.5			Dilution Water Demand Control—*ppm.*			
										Chlorine		Chlorine Dioxide	
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual	OTA Residual	OT Residual	OTA Residual
						20°C.							
0.005	0	0	73.5	0	0	4.55	trace	0	42.8	0	0	0	0
0.01	trace	trace	98.8	trace	0	53.0	0.01	trace	99.9	0.005	0.005	0.005	0.005
0.015	0.01	0.005	99.82	0.005	0	89.5	0.012	0.005	100	0.01	0.01	0.01	0.01
0.02	0.015	0.010	99.9	0.01	trace	99.83	0.015	0.01		0.015	0.015	0.015	0.015
0.025	0.02	0.02	100	0.015	0.005	99.86	0.018	0.015		0.02	0.02	0.02	0.02
0.037	0.03	0.03		0.025	0.01	99.9+	0.025	0.02		0.03	0.03	0.04	0.035
0.05	0.05	0.045		0.035	0.015	100	0.045	0.04		0.045	0.045	0.055	0.055
0.075				0.06	0.02					0.08	0.08	0.08	
						5°C.							
0.005	0	0					0	0	96.4				
0.01	0.005	0.005	27.8				0.005	trace	99.55				
0.015	0.01	0.01	89.2				0.01	0.008	99.99				
0.02	0.015	0.015					0.012	0.01	100				
0.025													
0.037	0.035	0.03	99.9+				0.03	0.025					
0.05	0.05	0.05	100				0.05	0.040					
0.075	0.08	0.08											

TABLE 4—*Average Per Cent Kill of* Salmonella paratyphi B

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7.0			Chlorine pH 7.0			Chlorine Dioxide pH 9.5			Dilution Water Demand Control—*ppm.*			
										Chlorine		Chlorine Dioxide	
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual	OTA Residual	OT Residual	OTA Residual
						20°C.							
0.01	trace	trace	61.5	0	0	39.0	trace	trace	0	trace	trace	trace	trace
0.02	0.005	0.005	74.4	trace	0	63.5	0.005	<0.01	22.4	0.005	0.005	0.01	0.01
0.03	0.015	0.01	88.5	0.01	<0.01	99.77	0.01	0.01	99.9+	0.015	0.015	0.015	0.015
0.04	0.025	0.02	99.14	0.02	0.005	99.9+	0.015	0.015	100	0.025	0.025	0.02	0.025
0.05	0.035	0.03	99.9+	0.03	0.01	100	0.02	0.02		0.035	0.035	0.035	0.035
0.075	0.06	0.055	100	0.055	0.025		0.04	0.035		0.065	0.06	0.06	0.055
0.10	0.09	0.08		0.08	0.06		0.07	0.06		0.095	0.09	0.09	0.09
						5°C.							
0.01	trace	trace	58.1				trace	trace	28.5				
0.02	0.01	0.008	74.4				0.005	0.005	99.88				
0.03	0.015	0.015	93.9				0.01	0.01	99.88				
0.04	0.025	0.025	98.0				0.02	0.015	99.9+				
0.05	0.030	0.030	99.4				0.025	0.02	100				
0.075	0.06	0.055	100.0				0.05	0.045					
0.10	0.085	0.08					0.075	0.07					
0.15	0.130	0.130					0.125	0.120					

broth culture and incubated for 24 hours. The organisms were then suspended in a small amount of physiological saline and washed by centrifugation to remove any organic matter that might have been carried over from the slants. The organisms were then suspended in saline and filtered through cotton to remove clumps and any agar particles which might have passed through the centrifugation. This suspension was then diluted so that 10 ml., when added to 2 liters of the demand-free water, would give a count of 10,000 bacteria per milliliter.

Bacteriological testing procedure. For each set of conditions and each gas, 2 liters of the buffered, ammonia-free, demand-free water was seeded with the culture and then divided into 200-ml. portions of sterile, acid-cleaned, glass-stoppered bottles. These were placed in a water bath at the desired temperature, and chlorine or chlorine dioxide was added from the 20-ppm. working solutions. The bottles were immediately shaken and allowed to stand for five minutes. Following this, 5 ml. was transferred to 5 ml. of neutralizing solution which consisted of 0.1 per cent thiosulfate and 0.1 per cent peptone. This neutralized bacterial suspension was then plated in duplicate with nutrient agar and incubated for 48 hours at 37°C. Controls were run with each variable condition of testing in the same manner as with the germicidal agent. This procedure gave the number of organisms that would be present at the end of the test interval in the absence of a germicide. Such information was necessary

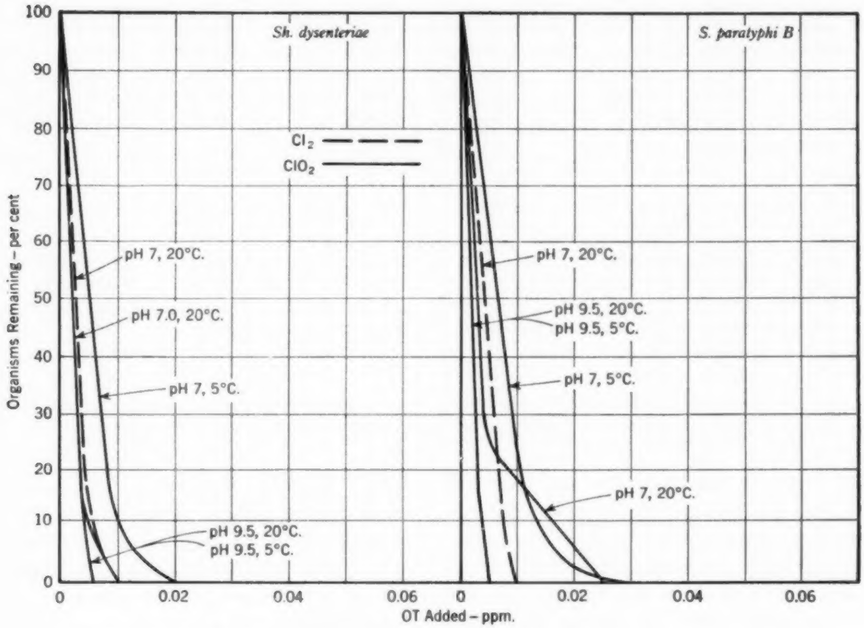

FIG. 2. Bactericidal Effect of Chlorine Dioxide (*Sh. dysenteriae* and *S. paratyphi B*)

TABLE 5

Average Per Cent Kill of Pseudomonas aeruginosa

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7.0			Chlorine pH 7.0			Chlorine Dioxide pH 9.5		
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*
				20°C.					
0.02	0.01+	0.01	93.9	<0.01	trace	10.0	trace	trace	99.4
0.03	0.02	0.02	99.88	0.015	0.01	12.7	0.01	<0.01	99.9+
0.04	0.028	0.028	99.9+	0.022	0.01	20.0	0.018	0.01	100
0.05*	0.04	0.04	100	0.03	0.015	66.7	0.025	0.018	
0.075	0.06+	0.06		0.055	0.018	99.9+	0.04	0.04	
0.10†	0.095	0.095		0.075	0.04	100	0.08	0.065	
0.15	0.14	0.14		0.12	0.055		0.12	0.11	
0.20				0.16	0.075				
				5°C.					
0.02	0.02	0.02	48.0				0.015	0.01	99.6
0.03	0.03+	0.025	80.0				0.02	0.02	99.9+
0.04	0.04	0.04	95.3				0.03	0.03	100
0.05	0.045	0.045	98.4				0.035	0.035	
0.075	0.07	0.07	99.9+				0.06	0.06	
0.10	0.095	0.095	100				0.07	0.07	
0.15	0.14	0.14					0.125	0.11	

* Dilution water demand control (OT, OTA residuals): chlorine—0.03; chlorine dioxide—0.04 ppm.
† Dilution water demand control (OT, OTA residuals): chlorine—0.08; chlorine dioxide—0.09 ppm.

in order to calculate the per cent kill due to the chlorine or chlorine dioxide and not that due to the pH or possible slight water toxicity. At pH 9.5 there was a noticeable water toxicity for the organisms, especially during the interval while the suspension was being taken down to 5°C. The possibility of bacteriostasis was checked at various points in the tests and found absent.

Measurement of chlorine and chlorine dioxide residuals. At the time of bacteriological sampling, the chlorine and chlorine dioxide residuals were measured on the same suspension by the ortho-tolidine (OT) and ortho-tolidine-arsenite (OTA) methods. In order to obtain accuracy as well as speed, 50-ml. comparator tubes were used. The tubes containing ortho-tolidine were allowed to reach maximum color before reading. At higher pH, it was necessary to add 1 ml. of concentrated sulfuric acid in order to obtain conditions for complete measure of the residuals.

Testing pH and temperature. Tests of *Esch. coli* and *Aer. aerogenes* were made at pH 7 and 9.5 at both 20° and 5°C. with both chlorine and chlorine dioxide. All other organisms were tested as above with chlorine dioxide, but only at pH 7 at 20°C. with chlorine.

Results of Study

The results of these studies under the above-mentioned conditions and meth-

ods are given in Tables 1–9 and Fig. 1–5. Tables 1–8 give the percentage kill, after five minutes of contact, of the different organisms tested as related to the weight of chlorine dioxide and chlorine applied; the OT and OTA residuals; and different pH and temperature conditions. Figures 1–5 show the percentage kill data plotted in curve form in relation to chlorine dioxide added on an OT basis.

For *Eberthella typhosa* (Table 1 and Fig. 1) and *Esch. coli* (Table 2 and Fig. 1), the results show that:

1. Except at 5°C. at pH 7.0, 0.025 ppm. of chlorine dioxide residual, measured on an OT basis, destroyed *Eberthella typhosa* within the temperature range of 5°C. to 20°C. Approximately 0.065 ppm. of residual chlorine dioxide was required at pH 7.0 at the low temperature of 5°C., and 0.06 ppm. of chlorine was required at pH 7.0 at 20°C.

2. *Esch. coli* was slightly more resistant than *Eberthella typhosa,* requiring 0.075 ppm. of applied chlorine dioxide at pH 7.0, 20°C.; 0.02 ppm. at pH 9.5, 20°C.; 0.15 ppm. at pH 7.0, 5°C.; and 0.03 at pH 9.5, 5°C.

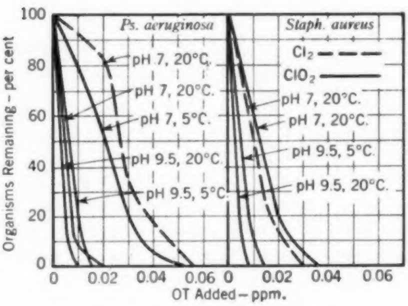

FIG. 3. Bactericidal Effect of Chlorine Dioxide
(*Ps. aeruginosa* and *Staph. aureus*)

3. The effectiveness of chlorine dioxide on these organisms definitely increased with increase in pH and also increased as the temperature rose.

4. In comparison with chlorine, chlorine dioxide is slightly superior at pH 9.5 for temperatures between 5° and 20°C. Chlorine is slightly superior to chlorine dioxide at pH 7.0 and 5° and 20°C. The differences between the two gases at either the higher or lower temperatures in the lower neutral range is, however, of doubtful practical significance.

For *Shigella dysenteriae* (Table 3 and Fig. 2) and *Salmonella paratyphi B* (Table 4 and Fig. 2), the results show that:

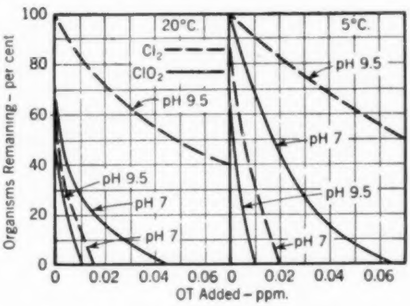

FIG. 4. Chlorine and Chlorine Dioxide Comparison
(*Aer. aerogenes*)

1. Destruction of *Shigella dysenteriae* was secured by chlorine dioxide with an OT residual of 0.02 ppm. at pH 7.0, 20°C.; 0.01 ppm. at pH 9.5, 20°C.; and 0.05 ppm. at pH 7.0, 5°C. By comparison chlorine destroyed the bacteria with 0.035 ppm. residual OT at 20°C.

Salmonella paratyphi B was more resistant than *Shigella dystenteriae* to chlorine dioxide, but the two organisms were about equally resistant to

chlorine. The order of resistance of *Salmonella paratyphi B* to both gases was, however, approximately the same under the same pH and temperature conditions. For instance, an OT residual of 0.06 ppm. chlorine dioxide by a comparison of the two gases at pH 7.0 at 20°C. for substerilization endpoints.

2. The effectiveness of chlorine dioxide again shows a definite increase with increase of pH as demonstrated

TABLE 6

Average Per Cent Kill of Staphylococcus aureus

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7.0			Chlorine pH 7.0			Chlorine Dioxide pH 9.5		
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*
20°C.									
									99.1
0.02	0.01	0.01	1.6	<0.01	trace	0	0.014	<0.01	95.9
0.03							<0.015	0.01	99.9+
0.04	0.02	0.02	30.6	0.022	<0.01	53.4	0.025	0.02	
						33.0			
0.05*	0.03	0.025	45.1	0.03	0.01	81.7	0.03	0.025	
0.075	0.05	0.05	89.0	0.06	0.022	99.7	0.055	0.05	
			93.0						
0.10†	0.07	0.068	99.3	0.07	0.03	99.8	0.070	0.068	
0.15	0.12	0.11	99.99	0.11	0.05	99.99+	0.11	0.10	
0.2	0.15	0.14	100	0.16	0.075	100			
5°C.									
0.02	0.01	0.01					0.010	trace	14.28
0.03							0.018	0.15	83.5
0.04	0.025	0.025					0.025	0.025	99.8
0.05	0.035	0.035					0.03	0.028	99.9+
0.075	0.055	0.05					0.055	0.055	99.9
0.10	0.08	0.08					0.075	0.07	100
0.15	0.125	0.125					0.12	0.11	
0.2	0.16	0.16							
0.25	0.19	0.19	95.7						

* Dilution water demand control (OT, OTA residuals): chlorine—0.03; chlorine dioxide—0.04 ppm.
† Dilution water demand control (OT, OTA residuals): chlorine—0.08; chlorine dioxide—0.085 ppm.

was required at pH 7, 20°C.; 0.015 ppm., at pH 9.5, 20°C.; and 0.06 ppm., at pH 7.0 at 5°C. A chlorine residual (OT) of 0.03 ppm. was required at pH 7.0, 20°C. Chlorine dioxide was more effective in partial kills than chlorine at the same OT residuals, as indicated in tests on previous organisms. This is in contrast to the well known decreasing effectiveness of chlorine with increasing pH.

3. In comparison with chlorine, chlorine dioxide, on an OT basis, shows superiority at pH 9.5, 20°C. and

5°C.; equality at pH 7.0, 20°C.; and some inferiority at pH 7.0, 5°C. Under any condition tested, chlorine dioxide showed effectiveness with an 0.06-ppm. OT residual.

4. *Shigella dysenteriae* was less resistant to chlorine dioxide than *Esch. coli* under any conditions tested. *Salmonella paratyphi B* was less resistant than *Esch. coli* at pH 7.0, 20°C.; pH 9.5, 20°C., and pH 9.5, 5°C. More resistance was indicated at pH 7.0, 5°C. Generally, therefore, *Esch. coli* is still a good test organism for sanitary quality when chlorine dioxide is used as a disinfectant.

For *Pseudomonas aeruginosa* (Table 5 and Fig. 3) and *Staphylococcus aureus* (Table 6 and Fig. 3), the results show that:

1. The organism *Pseudomonas aeruginosa* was destroyed by chlorine dioxide with an OT residual of 0.04 ppm. at pH 7.0, 20°C.; an 0.028-ppm. residual was needed at pH 9.5, 20°C.; 0.095 ppm., at pH 7.0, 5°C.; and 0.03 ppm., at pH 9.5, 5°C. The decreased efficiency in lower temperature ranges is offset by the increased efficiency in the higher pH ranges. The amount of chlorine OT residual required for disinfection was 0.075 ppm. at pH 7.0, 20°C. The rate of kill at subdisinfection doses is also greater with chlorine dioxide than with chlorine at the neutral pH and 20°C.

TABLE 7

Average Per Cent Kill of Escherichia coli

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7			Chlorine pH 7			Chlorine Dioxide pH 9.5			Chlorine pH 9.5		
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*
20°C.												
0.01	0.005	trace	68.5	0	0	85.97	trace	trace	24.6	0	0	0
0.02	0.01	0.01	64.9	0.005	trace	99.96	0.01	0.005	99.97			
0.03	0.025	0.02	88.8	0.015	trace	99.99	0.02	0.01	100	trace	trace	18
0.04	0.03	0.025	95.9	0.025	0.005	100	0.025	0.02	99.98	0.01	0.005	21
0.05	0.045	0.04	99.7	0.03	0.01	99.99	0.035	0.03	99.97	0.025	0.02	27.5
0.075	0.07	0.065	99.99	0.055	0.03	99.99	0.06	0.055	99.99	0.05	0.035	54
0.1	0.1	0.09	100	0.08	0.05	100	0.085	0.08	100	0.1	0.08	67.5
0.15										0.15	0.125	88.3
0.2										0.2	0.175	95.5
0.25												
5°C.												
0.01	trace	trace	34.5				trace	trace	55.5			
0.02	0.012	0.01	30.4	0.005	0	99.94	0.01	0.008	99.99			
0.03	0.025	0.02	64				0.02	0.018	99.97			
0.04	0.035	0.03	81.2	0.02	0.01	99.99	0.025	0.025	99.99	0.02	0.01	0
0.05	0.045	0.04	92.2				0.035	0.032	100			
0.06				0.035	0.025	99.99				0.03	0.02	20
0.075	0.07	0.065	99.7				0.06	0.06	100	0.055	0.04	51.7
0.10	0.1	0.09	100	0.075	0.05	100	0.09	0.085	99.99	0.10	0.075	48
0.15	0.15									0.15	0.125	72.6
0.20										0.20	0.175	79.4
0.25										0.25	0.225	84.25
0.3										0.35	0.325	81.8
0.4										0.45	0.335	91.5
0.5												

With the test organism *Staphylococcus aureus,* the amount of chlorine dioxide required on an OT basis was 0.15 ppm. at pH 7.0, 20°C.; 0.025 ppm. at pH 9.5, 20°C., over 0.19 ppm. at pH 7.0, 5°C.; and 0.055 at pH 9.5, 5°C. The chlorine required was over 0.16 ppm. at pH 7.0, 20°C. This organism thus demonstrates greater resistance than the preceding test organisms to both chlorine dioxide and chlorine, a fact which is to be expected as its relatively high resistance to disinfection is well known. The significant part of these data is that at pH 7.0, 20°C., the bactericidal action of chlorine dioxide and chlorine is about equal. At higher pH values, at either 20° or 5°C., the resistance of *Staphylococcus aureus* to chlorine dioxide falls markedly and comes within the disinfection range of other organisms previously studied. It is re-emphasized that neither of these organisms are considered as of significance in water supplies. Their value in an investigation of this kind is to permit a study of the action of the disinfectants on organisms of well known resistance characteristics. Both are hardier than the sanitary water test organism, *Esch. coli.*

TABLE 8

Average Per Cent Kill of Aerobacter aerogenes

Weight Applied (OT Basis) *ppm.*	Chlorine Dioxide pH 7			Chlorine pH 7			Chlorine Dioxide pH 9.5			Chlorine pH 9.5		
	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*	OT Residual *ppm.*	OTA Residual *ppm.*	Kill *per cent*
20°C.												
0.01	trace	0	98.1	0	0	13.8	trace	0	12.8			
0.02	0.008	trace	99.9	0.005	0	76.2	0.008	trace	34.9	0	0	3.25
0.03	0.015	0.01	99.8	0.01	trace	99.8	0.012	0.008	99.99			
0.04	0.025	0.02	100	0.015	trace	100	0.022	0.01	100	0.01	0	36.8
0.05	0.035	0.03		0.025	0.008		0.03	0.02		0.012	trace	11.25
0.06												
0.075	0.06	0.055		0.05	0.015		0.05	0.045		0.025	0.01	56.2
0.1	0.09	0.08		0.07	0.025		0.075	0.07		0.045	0.02	79.5
0.15				0.12	0.05					0.09	0.045	92.6
0.20										0.14	0.09	99.0
0.25										0.18	0.12	99.6
5°C.												
0.01	trace	trace	58.5				0	0	13.1			
0.02	0.01	0.008	95.9	0.005	0	93.4	0.008	trace	96.7	0	0	2.34
0.03	0.02	0.015	99.32				0.01	0.008	100			
0.04	0.03	0.025	99.92	0.015	trace	99.96	0.02	0.015		0	0	6.25
0.05	0.035	0.03	99.88				0.025	0.02				
0.06				0.03	0.01	99.96				0.01	0	18.78
0.075	0.06	0.055	99.96	0.04	0.02	100	0.05	0.045				
0.1	0.09	0.08	100	0.06	0.03		0.08	0.07		0.035	0.015	25
0.15	0.14	0.13		0.1	0.06					0.075	0.04	28.18
0.2				0.15	0.1					0.12	0.07	49.25
0.25				0.2	0.15							
0.30										0.2	0.15	71.9
0.5										0.38	0.3	97.3

2. The greater effectiveness of chlorine dioxide at higher pH is again

convincingly demonstrated in the tests on these two organisms.

3. With respect to *Pseudomonas aeruginosa* and *Staphylococcus aureus*, the effectiveness of chlorine dioxide and chlorine, on an OT basis, is in general approximately equal at pH 7, 20°C., but chlorine dioxide is considerably more effective at pH 9.5, at both 20° and 5°C.

Sanitary Test Organisms

In Table 7 and Fig. 4, and Table 8 and Fig. 5, the effects of the two gases on *Esch. coli* and *Aer. aerogenes* are more extensively compared than for organisms shown in the preceding tables. Although some previous data on the effects of chlorine dioxide on *Esch. coli and Aer. aerogenes* have been presented, more information was believed necessary because of their importance as sanitary test organisms. Added data of special significance included a more complete comparison of chlorine with chlorine dioxide at different pH and temperature levels. Previous data on other bacteria have been related to chlorine as well as chlorine dioxide but only at pH 7.0 and 9.5 at 20°C. Such data were believed adequate in these instances since the effects of chlorine at temperatures relative to 20°C. is well known (2). With information on chlorine dioxide at both high and low temperatures and high and low pH, a reasonable comparison of the two gases could thus be made. However, for the two sanitary test organisms, *Esch. coli* and *Aer. aerogenes,* a comparison of both gases was made at pH 7.0 and 9.5 and at temperatures of 5° and 20°C. These more complete data show that:

1. *Esch. coli* was effectively destroyed by chlorine dioxide, under all conditions of study, with a maximum OT residual of 0.1 ppm. This maximum was required at pH 7.0, 5°C. At higher temperatures and higher pH, the residual required for effective kill was less, amounting to as little as 0.02 ppm. at pH 9.5, 20°C. Chlorine was superior to chlorine dioxide in requiring less residual at pH 7.0 for both 5° and 20°C. but was definitely inferior at pH 9.5 at both temperatures.

2. The test organism *Aer. aerogenes* showed somewhat lesser resistance than *Esch. coli* to both chlorine dioxide

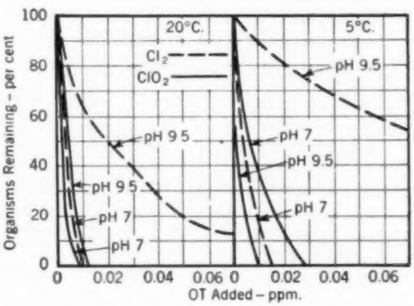

Fig. 5. Chlorine and Chlorine Dioxide Comparison (*Esch. coli*)

and chlorine. With chlorine dioxide, the maximum residual required for effective disinfection was 0.09 ppm. at pH 7.0, 5°C. The residual required for other conditions decreased to a minimum of 0.02 at pH 9.5, 20°C. For this organism also, somewhat lesser chlorine residuals were required for the same kill at pH 7.0, 5° and 20°C. The differences in required OT residuals were, however, small, amounting to 0.05 ppm. at 5°C. and 0.01 ppm. at 20°C. At the higher pH of 9.5, chlorine dioxide required less OT residual for equal kill. At the low

TABLE 9

Summary of Chlorine Dioxide and Chlorine Residuals Required for Kill of Various Organisms

Organism	Chlorine Dioxide			Chlorine		
	Weight* Applied	OT Residual	OTA Residual	Weight* Applied	OT Residual	OTA Residual
	ppm.					
pH 7, 20°C.						
Eb. typhosa	0.04	0.025	0.025	0.075	0.06	0.02
Sh. dysenteriae	0.025	0.02	0.02	0.05	0.035	0.015
S. paratyphi B	0.075	0.06	0.055	0.05	0.03	0.01
Ps. aeruginosa	0.05	0.04	0.04	0.10	0.075	0.04
Staph. aureus	0.20	0.15	0.14	0.20	0.16	0.07
Esch. coli	0.10	0.10	0.09	0.1	0.08	0.05
Aer. aerogenes	0.04	0.025	0.02	0.04	0.015	trace
pH 7, 5°C.						
Eb. typhosa	0.075	0.065	0.06			
Sh. dysenteriae	0.05	0.05	0.05			
S. paratyphi B	0.075	0.06	0.055			
Ps. aeruginosa	0.10	0.095	0.095			
Staph. aureus	>0.25	>0.19	>0.19			
Esch. coli	0.10	0.10	0.09	0.10	0.075	0.05
Aer. aerogenes	0.10	0.09	0.08	0.075	0.04	0.02
pH 9.5, 20°C.						
Eb. typhosa	0.05	0.025	0.025			
Sh. dysenteriae	0.015	0.012	0.005			
S. paratyphi B	0.04	0.015	0.015			
Ps. aeruginosa	0.04	0.018	0.01			
Staph. aureus						
Esch. coli	0.10	0.085	0.08	>0.25	>0.20	0.175
Aer. aerogenes	0.04	0.022	0.01	>0.25	>0.18	>0.12
pH 9.5, 5°C.						
Eb. typhosa	0.04	0.025	0.02			
Sh. dysenteriae	0.02	0.012	0.01			
S. paratyphi B	0.05	0.025	0.02			
Ps. aeruginosa	0.04	0.03	0.03			
Staph. aureus	0.10	0.075	0.07			
Esch. coli	0.05	0.035	0.032	>0.50	>0.45	>0.335
Aer. aerogenes	0.03	0.01	0.008	>0.50	>0.38	>0.30

* Weight applied on OT basis. Actual weight of chlorine dioxide applied is 1.9 times OT applied.

temperature and high pH, the difference in required residuals was strikingly in favor of chlorine dioxide.

3. With the test organisms used in this study, the same fundamental relationship between chlorine dioxide and chlorine seems to hold as with all other organisms previously tested; namely, at pH 7.0, 5°C., chlorine definitely requires less residual than chlorine dioxide for equal kill; at pH 7.0, 20°C., there is a slight but not too definite advantage to chlorine. The differences between the two gases at this pH and temperature is certainly of no practical significance. At higher pH (9.5), chlorine dioxide is definitely superior on an OT residual basis at both 5° and 20°C., with a striking advantage at the lower temperature of 5°C.

The detailed data of Tables 1–8 are summarized in Table 9, which shows the relative amounts of chlorine dioxide and chlorine required for 100 per cent kill in five minutes under varying conditions of pH and temperature. The amounts of chlorine dioxide or chlorine required to reach the 100 per cent kill endpoint are given with respect to weight applied and OT and OTA residuals at the end of the five-minute contact period.

Conclusions

From an inspection of the results given in the foregoing tables and curves, it would appear that the following general conclusions can be reached about the bactericidal properties of chlorine dioxide:

1. Chlorine dioxide, if applied in an amount to give an OTA residual of not less than 0.1 ppm., will destroy the common water pathogens, *Eberthella typhosa, Shigella dysenteriae* and *Salmonella paratyphi B,* at temperatures between 5° and 20°C. and at all pH values above 7.0, with a five-minute contact period. Lesser residuals are actually required, but it is believed that the stated value of 0.1 ppm. allows for a reasonable factor of safety in turbidity-free water such as was used in these studies. More resistant forms of organisms, *like Pseudomonas aeruginosa* and *Staphylococcus aureus,* required slightly higher residuals for complete kill.

2. As with chlorine disinfection, the sanitary test organism, *Esch. coli,* showed slightly higher resistance to chlorine dioxide than the water pathogens. This applied for all conditions of temperature and pH studied. The data thus show that the same sanitary test organism can be used for chlorine dioxide as for chlorine.

3. The effect of pH on the bactericidal efficiency of chlorine dioxide is definitely clear. For all organisms studied, lesser residuals are required for the same kill with increase in pH—or, the bactericidal efficiency of chlorine dioxide increases with increase in pH. This is the opposite of the effect of pH on the bactericidal efficiency of chlorine. This statement is clearly demonstrated by the comparison of the bactericidal effect of chlorine and chlorine dioxide on *Esch. coli* and *Aer. aerogenes* at pH 7.0 and 9.5 shown in Table 9 for both 5° and 20°C.

4. Usually the bactericidal effect of chlorine dioxide decreases somewhat with decreased temperatures, as does that of chlorine. At the lowest temperature studied, however, 0.1 ppm. was still adequate for disinfection against the common water pathogens.

References

1. Ridenour, G. M. & Ingols, R. S. Bactericidal Properties of Chlorine Dioxide. Jour. A.W.W.A., **39**:561 (June 1947).

2. Butterfield, C. T. et al. Influence of pH and Temperature on the Survival of Coliforms and Enteric Pathogens When Exposed to Free Chlorine. Pub. Health Repts., **58**:1837 (1943).

Editor's Note

In another paper, entitled "Sporicidal Properties of Chlorine Dioxide," * *Ridenour and Armbruster (in collaboration with R. S. Ingols, Assoc. Res. Prof., School of Civil Eng., Georgia School of Technology, Atlanta, Ga.) have compared the effect of chlorine dioxide, chlorine and chloramines on the spore-forming bacteria,* B. subtilis, B. megatherium *and* B. mesentericus. *The results of these studies may be summarized as follows:*

1. Chlorine dioxide is a more effective sporicide than chlorine if compared on an equal OTA residual basis.

2. The effectiveness of OTA residual from chlorine dioxide, as related to chlorine, seems to be greater on spores than on vegetative cells. The difference may be due to the residual potential of four additional valence changes in the chlorine dioxide molecule, which may, on spores, be more effective because the spore material is more reactive with the chlorine dioxide molecule.

3. Less weight of chlorine dioxide than of chlorine is required in either demand-free waters or in waters containing ammonia. The difference in weight required depends on the ammonia content. In ammonia-bearing waters, chlorine must be applied beyond the breakpoint before a sporicidal efficiency is obtained equal to that from chlorine dioxide.

4. It would appear from these investigations that chlorine dioxide could be used to control spore contamination in either water treatment plants or distribution systems. If the ammonia content of the water requires breakpoint application of chlorine for spore control, chlorine dioxide may offer a decidedly superior method of treatment.

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Characteristics of Activated Silica Sols

By Clarence R. Henry

A contribution to the Journal by Clarence R. Henry, Chief Chemist, Dept. of Water & Sewers, Miami, Fla.

IN recent years a great deal of interest has developed in activated silica as a coagulant or coagulant aid in water treatment. The use of silica sols, produced by the neutralization of the free alkali of sodium silicate solutions, offers many operating advantages. Some waters are very difficult to treat by ordinary methods. It is usual to expect that a water high in hardness may be softened by means of the lime or lime-soda process and that a small amount of alum or iron salts will coagulate the precipitate so that it will settle out readily. A soft, highly colored water should form a rather fine "color floc" at a pH of 5 or 6, and, once the optimum pH is established, the problem is largely one of feeding the amount of alum which will maintain this pH. Sulfuric acid may be used with the alum to lower the pH.

In some sections of the country, however, waters are found which are high both in alkalinity and organic color. These waters will not form a color floc until so much acid or alum is consumed in lowering the pH that not only is the cost prohibitive, but a much more expensive softening requirement remains than existed originally. Moreover, if softening alone is attempted, the organic color is only partially removed. This color, besides being objectionable, frequently acts to inhibit the action of the coagulant. Waters may exist in the same locality which have an apparently identical composition but behave quite differently upon treatment. The lime or lime-soda process may give a fairly large, rapidly settling floc with one water, while another will resist treatment to the extent that the floc particles are scarcely visible and little settling occurs. Water from the same source may also vary with the season, yet the study of a complete mineral analysis will do little more than indicate a probable type of action on softening.

The water near Miami, Fla., may be cited as an example. This city's supply comes from approximately 20 wells averaging 90 ft. in depth. On treatment with lime and 8.6 ppm. of alum, a fairly good floc is formed, which is greatly improved if the lime is added in excess; 17–34 ppm. over the "zero treatment" is required to convert all bicarbonates to carbonate, with no hydroxide present. These wells are located near the Miami Canal, the mineral analysis of which will not greatly differ from that of the average well, except in color. The Miami Canal water is different in character in that no amount of alum up to 137 ppm. will give a satisfactory floc. At the same time, a relatively small amount of activated silica will give satisfactory, though not excellent, results. Typical

average analyses of these two waters are shown in Table 1.

At times, therefore, it may be found that a water may no longer be successfully treated. In a conventional type of softening plant, there may be insufficient clarification on settling, so that filter runs are greatly reduced. In an upflow type of softening unit, no sludge blanket or bed may be built up, the sludge formed being so fine that it is carried over in the effluent water. In the preliminary search for a source of water, the chemist-engineer-designer team may find a plentiful supply, but experimental treatment may indicate that the floc formed is too fine and light to give satisfactory operation.

TABLE 1

Typical Average Analysis

	Miami Well Water *ppm.*	Miami Canal Water *ppm.*
pH	7.3	7.6
Color	60.	120.
Ammonia nitrogen (N)	0.50	0.24
CO_2, free	21.	12.
Total dissolved solids	350.	360.
Turbidity	0	0
Silica (SiO_2)	9.0	7.8
Iron, total (Fe)	0.9	0
Calcium (Ca)	98.	91.
Magnesium (Mg)	7 1	7.8
Sodium and potassium (Na)	27.	7.7
Alkalinity ($CaCO_3$):		
$OH-CO_3-HCO_3$	0–0–220.	
Sulfates (SO_4)	37.	19.
Chlorides (Cl)	35.	24.
Hardness, total ($CaCO_3$)	250.	260.
Hardness, noncarbonate ($CaCO_3$)	30.	40.

Numerous methods for preparing silica sols are known. These include the 85 per cent neutralization of the Na_2O content by H_2SO_4—Baylis (1)—the partial neutralization by another coagulant, alum—Baker and Dedrick (2)—and the complete neutralization—Graf-Schworm (3)—to "any acid-forming substance" (2, 4). One method, neutralization by carbon dioxide gas, is attractive to those plants already using this gas as part of the existing process, or where it may be easily made available. Moreover, preliminary work has indicated that sols so prepared would be active throughout a much wider range of neutralization, and would be much more stable, than those made by the use of a strong acid. Although sols made with ammonium sulfate are also stable and easy to prepare, the ammonium ion added to the water will greatly increase the cost of free residual chlorination. Sols made from sodium bicarbonate have the desirable characteristics but involve the purchase of an additional chemical, whereas the carbon dioxide is nearly free.

The work described in this paper was undertaken to develop data on the character of sols prepared by the use of carbon dioxide gas. From the standpoint of water plant operation, it was considered very desirable that the preparation should be as simple as possible and should be controlled by reliable test methods. It was also believed important to know for what length of time after preparation these sols would remain active and how long they might be stored before a whole tank became solid and interrupted an entire plant's operation. The pH, percentage of neutralization, stability and activity were studied in order that the preparation of the sol might be controlled and that efficient design of preparation and storage equipment might be possible. Stability was observed for several concentrations of SiO_2 to determine the effect

of age upon the stability of the various sols. The rate of absorption of carbon dioxide, in the concentration usually available for plant use as scrubbed burner or stack gas of 10 per cent CO_2 strength, was observed for several rates of flow and different tank depths on a pilot plant scale.

Experiments

All sols were prepared from N silicate of soda (produced by the Philadelphia Quartz Co.) having an approximate composition of 8.9 per cent Na_2O, and 28.7 per cent SiO_2; a density of 41° Bé; and a weight of 11.6 lb. per gallon. Two-liter batches were prepared by rinsing 50.7 ml. of the sodium silicate into 2-liter volume with distilled water for each 1.0 per cent SiO_2 desired in the finished sol. Pure carbon dioxide gas was introduced through a ¾-in. fritted-glass diffuser plate at the bottom of a 2-liter glass beaker and just below a metal stirrer connected to an electric motor. The temperature throughout the period of observations was approximately 25°C. The apparatus is shown in Fig. 1.

The labeling and identification of the various samples reserved for stability observations were facilitated and greatly simplified by the use of the expression "$\%SiO_2 \times A\%$," in which "$\%SiO_2$" gives the strength of the sol in percentage SiO_2, and "$A\%$," the degree of neutralization of the Na_2O by the activating agent. For example, "1.5% $SiO_2 \times CO_2$ 65.5%" would describe a sol containing 1.5 per cent silica whose sodium oxide was 65.5 per cent neutralized by carbon dioxide.

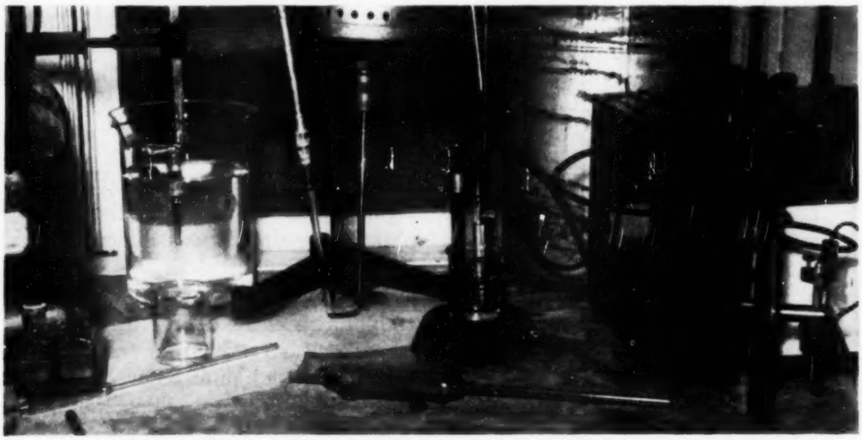

FIG. 1. Apparatus for Preparation of CO_2-activated Silica Sols

The pH was measured by means of a Model *G* Beckman glass-electrode pH meter. The special blue-glass electrode was used for the higher pH measurements. Readings were taken both during the addition of the carbon dioxide gas with stirring and on 100-ml. portions withdrawn by means of a 50-ml. pipette whose tip was cut off for speed in operation. From these portions 10.0-ml. titration samples were taken.

Stability Determination

Stability, or gelling time, was determined as the age of a sol at which it would just resist free flow. Samples were poured from the 100-ml. reserve portion into 22 × 175-mm. test tubes, which were tightly stoppered and placed in racks when half full. Before gelling, a period of increasing turbidity, opalescence and viscosity was observed on holding the tubes in a horizontal position and gently tilting them back and forth. Gelling time was taken when definite resistance to free flow could be observed. The sol would later develop more or less solidly and rapidly, depending on the concentration and degree of neutralization. In order to determine what effect the size of the sample contained might have upon the observed gelling time, several such determinations were also made using smaller test tubes, 250-ml. and 2-liter beakers, and a 1-gal. glass bottle for each separate batch of sols. The gelling time so measured was in close agreement for all sizes of containers used. Figure 2 shows the results of gel time observations on sols containing 0.5, 1.0, 1.5, 2.0 and 3.0 per cent SiO_2.

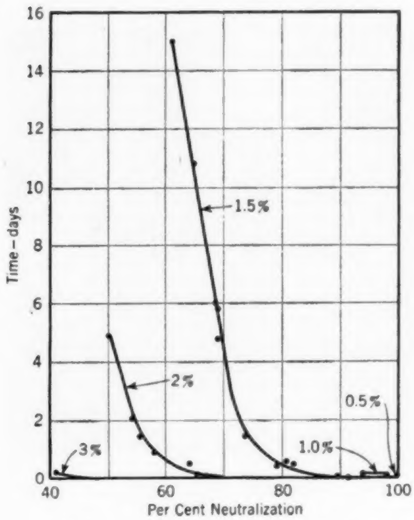

Fig. 2. Stability of Silica Sols

Percentage Neutralization

The percentage neutralization was determined by the same general method of differential titration with two indicators as is used in the determination of alkalinity in water (5). A 10.0-ml. sample was diluted with boiled distilled water to 50.0 ml. and titrated with 0.100 N H_2SO_4 using phenolpthalein and methyl orange indicators to calculate the proportion of hydroxide, carbonate and bicarbonate present. For a 10.0-ml. sample, each milliliter of acid is equivalent to 500 ppm. of alkalinity as $CaCO_3$. As the phenolphthalein endpoint was difficult to fix, 1.0 ml. phenolphthalein was used with six drops of methyl orange added. The endpoint was taken as the point at which a clear yellow color resulted with no redeveloped pink color on further addition of 0.25 ml. phenolphthalein. The methyl orange endpoint was run to a distinct pink color. Alkalinities were calculated as uncorrected $CaCO_3$ alkalinity in parts per million in the order: hydroxide–carbonate–bicarbonate. A sample whose alkalinity was calculated as 0 ppm. hydroxide, 5,600 ppm. carbonate and 1,800 ppm. bicarbonate would be entered as "0–5,600–1,800."

The percentage neutralization was calculated on the basis of 100 per cent conversion to bicarbonate. In this manner, a sol whose alkalinity was 4,500–3,700–0 would be considered 20 per cent neutralized. Likewise, an alkalinity of 0–7,600–0 would be 50

per cent, and an alkalinity of 0–0–7,600 would be 100 per cent neutralized.

The percentage neutralization measurements were made to give the curve of Fig. 3, covering four different runs. It will be noted that several variations appear, which are believed to be due to the operation and to operational difficulties of the glass electrode in this system. Cleaning and re-zeroing of the glass electrode must be done very frequently, perhaps too often to be practicable. The excessively moist atmosphere prevailing could also have introduced some error. On standing, the various sols reserved for stability observations showed some shift, both in pH and in alkalinity. It is believed that the pH–neutralization curve represents a true picture of results obtainable under optimum conditions only.

Two colorimetric pH indicators were observed which were in good agreement with the glass electrode. Since no break occurs in the pH curve, there is little to recommend them for the control of the preparation of a sol except as a very general danger signal for the quick approach of overneutralization. Phthalein red covers the upper part of the critical pH range but changes too slowly and gradually for safety in control. Thymolphthalein is somewhat better because, when the 5-ml. test tube of the usual commercial type of comparator is used, some margin of safety is possible. Viewed across the tube against a white background, the distinct blue color of the indicator fades to a very faint blue at the critical point of neutralization of the 1.5 per cent SiO_2 sols.

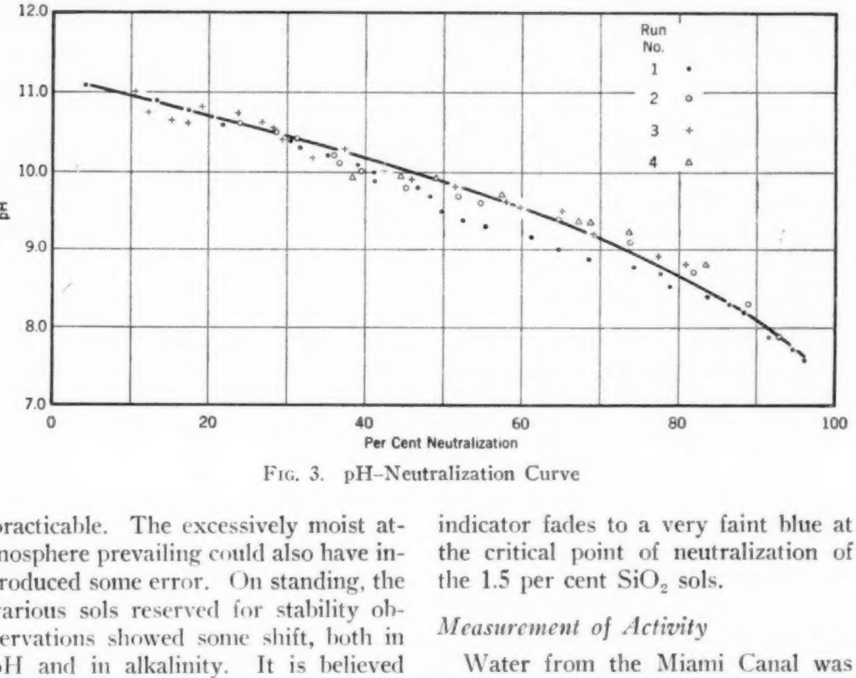

FIG. 3. pH–Neutralization Curve

Measurement of Activity

Water from the Miami Canal was used for testing the activity of carbon dioxide–activated silica sols as a coagulant in softening water with lime. This water is quite difficult to treat and was believed to be more suitable for a comparative test than an easily treated one. The turbidity of the untreated raw water is quite low and,

moreover, the character of the floc formed on softening is little affected by slight variations in the amount of lime used. The amount of floc in suspension after fifteen minutes' settling, measured as turbidity, was used to compare the activity of the sols. A dosage of silica was selected which was just less than that necessary to give the average turbidity produced by successively larger doses. In the test, this silica dose (2.0 ppm. SiO_2) was applied to a series of jars of untreated water while being stirred at 160 rpm. This was immediately followed by the same quantity in all jars of a milk of

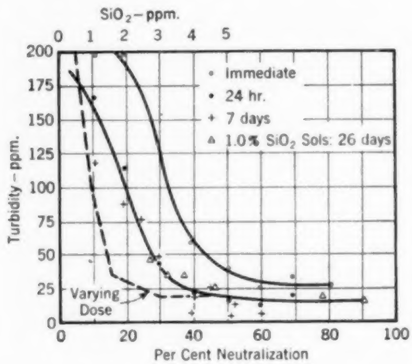

FIG. 4. Activity of Silica Sols

lime suspension to give a "zero-treated" water (final alkalinity of 0–X–0). Rapid stirring continued for 5 minutes after the addition of the lime, followed by fifteen minutes of slow stirring (40 rpm.) and finally by fifteen minutes of settling with no stirring. Samples were taken immediately with the sampling pipette, 2 in. below the surface, placed directly in 150-mm. cell depth and read as turbidity on the Lumetron 450 photoelectric colorimeter. The broken line in Fig. 4 shows the turbidity results of the varying silica dose (0.5–5.0 ppm. SiO_2) from which the 2.0-ppm. comparative test dose was selected; also shown are turbidity determinations—using 2.0 ppm. SiO_2—of a series of sols tested immediately (sols were diluted in less than ten minutes to a working concentration of 0.2 per cent for use 30 minutes later), after 24 hours and after seven days before such dilution.

Pilot Plant Tests

The neutralization of 1.5 per cent SiO_2 sols by means of scrubbed 10–11 per cent CO_2 gas produced by burning fuel oil was studied on pilot plant scale. The experimental unit con-

TABLE 2

Absorption of CO_2 by SiO_2 Sol

CO_2 Gas *cfm./sq.ft.*	Alkalinity Conversion ($CaCO_3$) *ppm./hr.*	Neutralization Change *per cent/hr.*
5-ft. Tank Depth		
1.	4,000	26.
2.	8,000	51.
14-ft. Tank Depth		
0.5	1,200	7.6
1.	2,700	18.
2.	7,000	44.

sisted of a 10-in. pipe 18 ft. long, set vertically to operate as a variable depth tank. The gas was forced through sixteen $\frac{1}{8}$-in. holes drilled in a pipe crossed at the bottom. All measurements of CO_2 concentrations were made with an Orsat apparatus, and neutralization was measured by titration with H_2SO_4, as previously described. The volume of gas was measured just before use so that tank depth was the same as the head against which the gas was pumped. Even at the lowest flow rate of the gas, 100 per cent absorption was not attained.

Absorption decreased as the neutralization of the sol proceeded and was somewhat less at the top of the tank than at the bottom. The solution as titrated before any gas was added gave an indicated neutralization of 12–14 per cent. These facts are recognized in the "Alkalinity Conversion" and "Neutralization Change" columns of Table 2. When measurable differences were found—at the top and the bottom of the tank, for example—average values are given.

Discussion

It appears from a study of the curve of Fig. 3 that control of the preparation of the CO_2-activated silica sols by means of pH would be difficult. This fact would be somewhat counterbalanced, when using the glass electrode during the addition of the gas with stirring, by the tendency for pH to be indicated approximately 0.2 units lower than the pH at equilibrium. The use of thymolphthalein to show the approach of 50 per cent neutralization at the observed pH of 9.5 might be indicated under some conditions. There is some shift in both pH and alkalinity after a period of time. The laboratory results obtained were somewhat erratic but generally on the order of an increase of 0.2 in pH and a decrease of 5 per cent in the calculated neutralization. It is believed that the neutralization is better controlled, and tests of aging sols are better accomplished, more reliable and more nearly reproducible, by the calculation of percentage neutralization using the method of titration outlined in this paper.

Observations indicate that the stability of a silica sol is dependent upon its concentration and upon the degree to which it has been neutralized. The weaker concentrations require not only complete conversion of Na_2O to $NaHCO_3$, but some free carbon dioxide as well, for complete and immediate gelation. Stronger sols will gel in a very short time when activated only beyond the Na_2CO_3 (50 per cent neutralization) stage or sooner.

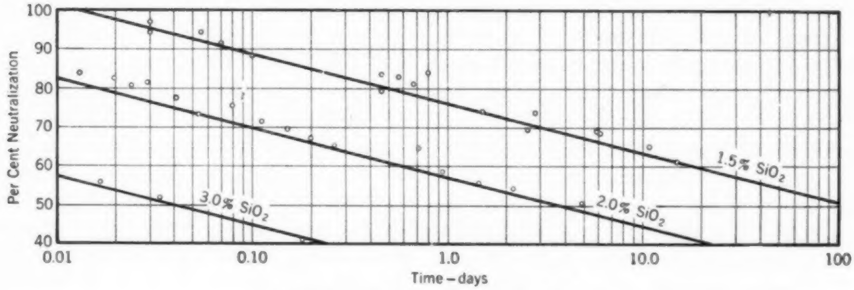

FIG. 5. Stability of Silica Sols

The activity of a sol, and its ability to perform the function of a coagulant or coagulant aid, is not impaired by the approach of gelation. Until a sol has ceased to be a liquid and resists free flow, it will behave as well as a sol of the same concentration that has either been aged less or that is somewhat less neutralized. At the other extreme—underneutralization—age alone, within a limited range, will improve the activity of a sol. Moreover, the less completely neutralized sols which become solid gradually may

still be used while in the semiliquid stage. Two sols, 61.2 per cent and 68.9 per cent neutralized, which gelled in sixteen and six days, respectively, were tested for activity as a coagulant in water softening the day following the time they resisted free-flow gelation. Both were viscous and semiliquid, with a few soft lumps loosely adhering to the side of the containing tube. The turbidities, after a similar jar test, were 52 and 38 ppm., respectively (compare Fig. 2 and 4).

A concentration of 1.5 per cent SiO_2 was selected as giving the best working stability while permitting a small storage tank space for the prepared sols. The 2.0 per cent concentration, however, may be used where control of all operations is assured. The 3.0 per cent solution is not recommended for the usual plant, although it would be preferable for a continuous-activation, immediate-feed design. From Fig. 2, it appears that 1.5 per cent SiO_2 sols may be neutralized with carbon dioxide to the point of 65 per cent conversion to the bicarbonate, and will then be stable for well over a week. Figure 4 indicates that the sol should be more than 50 per cent neutralized for immediate use and may be employed up to the point of 100 per cent neutralization, as long as gelation has not occurred. For use after 24 hours, the minimum efficient point is lowered to 40 per cent, the allowable maximum in each instance being that at which gelation may begin. These data indicate that 1.5 per cent SiO_2 sols should generally be 50 per cent neutralized. Conditions of use, however, may set a lower limit of 40 per cent or a maximum dependent solely on the required stability of the sol.

The approximate stability of a sol may be calculated. Figure 5 includes the same data as Fig. 2, plotted on a semilogarithmic scale. The curves represent empirical equations and define the trend of stability.

For 1.5 per cent and 2.0 per cent SiO_2 sols, the equation is:

$$A = \frac{114}{C} - 13 \log T$$

For 3.0 per cent SiO_2 sols, the equation is:

$$A = 32 - 13 \log T$$

in which A is the percentage neutralization, C is the concentration of sol as percentage SiO_2 and T is the time in days.

Acknowledgment

This work was performed for the Dept. of Water and Sewers, Miami, Fla. Thanks are due to A. P. Black, Prof. of Chemistry, Univ. of Florida, Gainesville, Fla., for his suggestions during the progress of the work; to R. J. Brehm, for his assistance in the laboratory; and to C. F. Ruff, for his aid in the preparation of the manuscript.

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Increased Water Consumption in Canada

By H. R. Hooper

A paper presented on April 27, 1949, at the Canadian Section Meeting, Quebec, Que., by H. R. Hooper, Engr. of Distr., Water Works Dept., Ottawa, Ont.

WATER consumption in Canadian municipalities has increased to such an extent during the period 1938 to 1948 that 54 towns and cities throughout the dominion have found it necessary either to enlarge the capacity of their systems or to recommend that the required improvements be undertaken immediately. Water is the life stream of any community, and, with the rapid advance being recorded in population, industry and standard of living, this increased consumption is definitely essential to the nation.

The information contained in this paper is a summary of the replies received to a questionnaire sent to all members of the Canadian Section of the A.W.W.A. Approximately 270 responses were received from water works officials representing the various communities. Of these, however, only 79 communities, with populations ranging anywhere from 5,000 up to 1,350,000, gave sufficient information to make a comparison over the last ten years. This report is therefore based on these 79 returns. Actually, only 75 communities are being considered, as four replied that they had reduced their consumption during the ten-year period. The reason given by three of these towns was that several leaks had been discovered and repaired. In the fourth area, the decrease in consumption was a result of reduced industrial activity after the war. All of the other 75 communities reported increased consumption.

Just prior to the war the main concern was to keep water consumption to a bare minimum in order to reduce expenditures for power and chemicals. Today, although still endeavoring to reduce costs, Canadian water utilities are primarily interested in meeting the ever increasing demands both for industrial and residential use.

Table 1 gives a summary of the answers to the question: "To what do you consider the increase in consumption to be due?" It will be noted that some correspondents gave two or more reasons. The two chief causes were increased population and increased industrial use, which will be dealt with in that order. High temperature and drought are a small contributory factor, but, as the increase in consumption has been constant year after year, they do not affect the result to any great extent. New homes and offices, together with the higher standard of living, are partially taken into account in both the first and second causes, as is air conditioning to some extent. Waste, or unaccounted-for water, although not listed as a factor in increased consumption by any of the 75 communities, is nevertheless of substantial importance in considering the consumption problem.

Increased Population

The total employed population of Canada increased approximately 1,350,000 from 1939 to 1947, and during the same period the total number of non-agricultural workers rose more than 1,450,000. These figures indicate a large shift of population from rural to urban employment, which may well be due to "an export volume of unexpected proportions [that] developed because [of] the enormous credits and direct gifts . . . provided by the United States and Canada to assist in the economic recovery of the United Kingdom and the nations of western Europe" (1). Naturally, with the addition of such a great number of urban water users, consumption had to rise. Water works officials who gave increased population as one of the main reasons for the increase in water consumption are certainly supported by the facts.

Not only has the total consumption leaped ahead, however, but the per capita consumption has also increased, although to a lesser extent when the amount used by industry is deducted. This per capita rise is due to Canada's improved standard of living, which "has risen 50 per cent since 1939 and is now second only to that of the United States" (1).

Increased Industrial Use

A very prominent engineer from a city of approximately 250,000 consumers, stated in his reply to the questionnaire that: "The increase in consumption is due to a small increase in population, but is chiefly due to an increase in industries, house building and the use of air-conditioning and refrigeration equipment." In this city, the increased population amounted to approximately 25,000, while the consumption increased 3.6 mgd. The per capita consumption in this 100 per cent metered community is 72 gpd., including industries. Allowing 40 gpd. per person would account for a consumption increase of 1 mgd., leaving 2.6 mgd. still to be accounted for. Evidently, a considerable amount was consumed by industries, with most of the remainder being used for new homes and air-conditioning and refrigeration units. The low per capita consumption, even including industries, indicates that the percentage of unaccounted-for water is very small.

Another example is provided by a Canadian city with a population of slightly less than 200,000. Although only the industries and large apartment houses and commercial properties were metered, two-thirds of all the increased consumption of water in this city was registered. Table 2 shows the great growth in metered industrial consumption.

TABLE 1

Causes of Increased Consumption

Cause	No. of Utilities
Increased population	75
Increased industrial use	53
High temperature and drought	23
New homes and offices	5
Air conditioning	4
Higher living standard	2
Waste	0

In the period 1938–48 the average consumption has increased 7,436,000 gpd., and the metered consumption by industries, 4,978,400 gpd. The population increase amounted to 33,000, and, allowing 40 gpd. per person, this represents an increased consumption of 1,320,000 gpd. There still is a balance of 1,137,600 gpd., which is placed under the heading of unaccounted-for water, dealt with elsewhere in this paper. Although the above facts apply to one of Canada's larger com-

munities, it is certainly not known as an industrial city. Yet the rise in consumption has been so pronounced that it appears to be a concrete example of the effect of increased industrialization.

Canada has become the third greatest industrial power in the world, in the short space of 35 years (1). In 1914 agriculture represented 43.1 per cent of the nation's net production, and manufacturing, 35.9 per cent. In 1948 the figures were drastically altered, with agriculture representing only 19.6, whereas manufacturing had risen to 65.1 per cent. From 1939 to 1943–44, industrial production in Canada doubled in dollar terms.

TABLE 2

Metered Industrial Consumption, 1938–48

Year	Average Use	Average Industrial Use	Total Use Per Capita	Nonindustrial Use Per Capita
	gpd.			
1938	17,437,000	5,716,000	109	81.1
1941	19,308,000	6,594,000	111.1	82.3
1946	23,847,000	9,469,000	124	86.7
1948	24,873,000	10,694,000	131	87.8

Once again the findings agree with many of the replies to the questionnaire and certainly explain the large increases in consumption—particularly in industrial centers—as well as the increased per capita consumption.

New Homes and Offices

The additional industries and increased population, together with a higher standard of living, necessitated providing homes for the workers. Consequently, large housing projects have been constructed, each unit equipped with the most up-to-date water works accessories. The provincial boards of health insist, and rightfully so, that all of these new homes must be assured of a clear, wholesome water supply. The result is that there are now thousands of families using modern water and sewage systems who previously relied on the old hand pump or well.

The higher standard of living is entering not only into home and social life but into business life as well, even into the very heart of industry. In the war era manpower was at a premium, and in order to preserve what was available, it was necessary to look after the welfare of the workers. Plants were equipped with rest rooms and recreation centers. The very finest lavatories were installed, with modern showers. Large department stores and restaurants followed suit by providing lounges and powder rooms for the public. Everyone is very proud of the new buildings and modern practices, but the fact remains that more and more water is required for them.

Air Conditioning

Although many water officials have not given serious thought to the increased consumption due to air conditioning, some have felt its effect very seriously, particularly at peak summer consumption. It is essential that this matter be given consideration by water works men faced with the problem of rising demand.

Unaccounted-for Water

As the reasons previously discussed account for only 75 to 90 per cent of the increased consumption, the problem of lost water gains in significance. In municipalities where all water is metered the unaccounted-for portion is much smaller and the per capita consumption much lower than where only industries and the like are metered. According to the replies to the questionnaire, the average per capita consumption was 51 gpd. less for municipalities with 100 per cent metering than for those not fully metered. Actually, the per capita figure for universally metered communities is almost 40 per cent less than for those not completely metered. It is obvious, therefore, that waste plays a most important part in increased water consumption, particularly in those communities where only a comparatively few services are metered.

The loss of water through underground leaks has increased in a number of Canadian cities where winter conditions are severe and where the insulating layer of snow is completely removed from the roadways. For instance, in 1948 Ottawa, Ont., had 55 broken water mains, 5 in. in diameter or larger. This number of breaks located and repaired represented an increase of 200 per cent over the average in the previous nine years.

Conclusions

There has been a considerable increase in water consumption due to additional population and an even greater increase due to increased industries, with higher living standards a contributing factor to the rise in both residential and industrial use.

In communities where all services are metered, the per capita consumption is being kept at a reasonably low figure. In areas where individual services are not metered, however, the consumption is so much higher that, if 100 per cent metering were in effect, the water departments in these communities could supply a 30 per cent greater population, and likewise a 30 per cent increase in industry, without enlarging the capacity of pumping or purification plants.

The effects of air conditioning are just beginning to be felt and before long will be a large factor in water consumption unless immediate steps are taken to control the use of city water for this purpose.

A considerable saving can be made in waste water inside homes by: [1] maintaining a well organized waste water inspection department; [2] educating the consumer to the necessity of conserving water and showing him the actual amount of water and money lost through needless waste (a public relations office is of inestimable value in this respect); and [3] metering every service.

A marked improvement in losses due to underground leaks can be achieved by an efficient waste water survey unit. With the present practice of snow cleaning in operation, this unit will have to be continuously operated year after year. The savings effected, however, both from this survey and from reducing the waste in homes, may well be sufficient to enable much greater populations to be served without the necessity of increasing production.

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Rainfall and Runoff in Virginia

By Donald S. Wallace

A paper presented on Oct. 25, 1948, at the Virginia Section Meeting, Richmond, Va., by Donald S. Wallace, Comr., Div. of Water Resources, State Dept. of Conservation & Development, Charlottesville, Va.

THERE is no simple equation giving the relationship between rainfall and runoff; neither is it possible to determine accurately such phases of the hydrologic cycle as evaporation, transpiration and ground water changes. Some of the important factors involved in runoff and ground water recharge are the type of bedrock, the geologic structure, the type of soil, vegetal cover, topographic relief and intensity and distribution of rainfall.

Over an area as large as Virginia, there is quite a variation in the relative effect of these factors. For instance, in parts of the Shenandoah Valley where limestone is close to the surface and several geologic faults exist, there is more rapid ground water recharge than in parts of the Piedmont where there are thick soil coverings of clay or clay loam.

Although the influence of topography and vegetal cover is important, the one factor which is most significant is the intensity and distribution of rainfall. A slow rain of 1 in. over 24 hours may not cause any runoff, but 1 in. of rain in one hour on top of a saturated soil may result in high runoff. A forested area might absorb the first 2 in. of precipitation if it came gradually, but when the forest litter and soil had absorbed water to near the saturation point, a heavy, intensive rain immediately thereafter might result in a very high percentage of runoff. Half an inch every third day would amount to about 60 in. annually, which, under existing conditions, would be a very wet year with full streams and wells. Yet, if it were possible to distribute the annual rainfall so that a slow rain of ½ in. occurred every third or fourth day, an apparently paradoxical situation would result in the summer. There would be lush vegetation and good agricultural conditions but little water in the streams and practically none in the ground to supply wells. Heavy rains—even floods—are needed to keep surface runoff high and wells full. Nearly all the water which enters the underground formations supplying the springs and wells comes from heavy rains which are sufficient, first to soak the topsoil, and second to penetrate the underlying soils and rocks.

Actually, Virginia's rainfall pattern is one which often includes long dry spells followed by very heavy rains. The total precipitation for the year may therefore be nearly normal, but both a severe drought and a high flood may have occurred in the same year, with first a ground water loss and then a recharge. Another year with the same total rainfall evenly distributed may have good vegetation but small stream flow and little ground water recharge. Still another year, like 1930, may have so little rain that not only are the

TABLE 1—*Annual Runoff for Representative Virginia Rivers*

River Measurement Station	Drainage Area *sq. mi.*	Annual Runoff—*in.*			
		1930	1937	1941	1946
Piedmont					
Rappahannock–Fredericksburg	1,599	5.69	27.07	9.09	14.01
James–Cartersville	6,242	7.00	23.16	8.40	12.77
Roanoke–Clover	3,230	7.07	21.84	8.41	13.35
Dan–South Boston	2,730	8.17	22.52	9.31	13.33
Appomattox–Mattoax	729	5.89	22.77	7.02	14.70
South Anna–Ashland	393	5.08*	24.06	7.09	13.33
Nottoway–Stony Creek	586	8.09*	20.12	6.72	15.55
Means		6.71	23.08	8.00	13.86
Appalachian-Valley					
Roanoke–Roanoke	388	5.27	18.48	6.10	12.17
New–Eggleston	2,941	10.53	21.61	10.76	19.85
Clinch–Speer Ferry	1,126	9.38	21.39	8.19	16.49
James–Buchanan	2,084	6.62	21.65	8.39	12.88
Middle–Grottoes	360	4.87	19.56	6.88	9.31
N.F. Shenandoah–Strasburg	772	4.04	15.46	6.23	9.01
Means		6.78	19.69	7.76	13.28
Tidewater					
Mattaponi–Beulahville	619				15.21
Chickahominy–Providence Forge	249				17.70
Blackwater–Zuni	448				14.13
Means					15.68

* 1931.

stream beds dry and vegetation or crops killed, but there is an actual loss from the ground water reservoir as well.

On a basis of averages, the amount of monthly precipitation is not badly distributed; that is, the mean for the winter months is not too much less than that for the summer. Yet normally the months of heaviest precipitation—from June to August—are also the months of heaviest transpiration losses. Hence, the lighter rains during the late fall, winter and early spring contribute much more to the surface and ground water supplies than the heavier rains of summer. This is true unless there is a tremendous outpouring of 6–20 in. during some hurricane storm, which, of course, replenishes surface and ground waters rapidly.

The U.S. Geological Survey, in cooperation with the Virginia Dept. of Conservation and Development, has been engaged for a good many years in the study of the ground and surface water resources of the state. In the

TABLE 2—*Elements of Hydrologic Cycle for Major Virginia Regions*

Region	Rainfall	Runoff	Evapo-transpiration	Change in Ground Water Storage
	in.			
1930				
Piedmont	24.2	6.7	20	−2.5
Appalachian–Valley	23.7	6.8	20	−3.1
Tidewater	28.5	7*	20	+1.5
State	24.9	6.8	20	−1.9
1937				
Piedmont	57.1	23.1	30	+4.0
Appalachian–Valley	49.7	19.7	30	0
Tidewater	54.2	20*	30	+4.2
State	54.0	21.3	30	+2.7
1941				
Piedmont	31.8	8.1	23	+0.7
Appalachian–Valley	30.1	7.8	23	−0.7
Tidewater	30.6	8*	23	−0.4
State	31.0	8.0	23	0
1946				
Piedmont	39.9	13.9	25	+1.0
Appalachian–Valley	35.3	13.3	25	−3.0
Tidewater	42.5	15.7	25	+1.8
State	38.8	14.0	25	−0.2

* Estimated.

surface water field, approximately 160 gaging stations are now operated, nearly 50 per cent of which have 20 or more years of record; at four points there are 50 years of record. Data are being collected also on the chemical character of these waters. Extensive studies have been made on the ground waters of the coastal plain, or Tidewater, and the Shenandoah Valley. Ground water data for the rest of the state are more limited, but it is hoped to enlarge the ground water program during the next few years.

An analysis of the water resources of Virginia generally starts by dividing the state into three main regions: the coastal plain, or Tidewater; the Piedmont; and the Appalachian–Valley. The first region is that between the shoreline and the fall line; the second, that between the fall line and the Blue Ridge Mountains; and the third, all the area west of the Blue Ridge. There are marked differences in the quality of the water in these regions: the waters in the Valley region are hard and alkaline (except for the small streams draining the sandstone or shale mountain ridges); those in the

Piedmont are very soft, with much silt or suspended matter in the streams; and those in the Tidewater are soft but highly colored.

The runoff characteristics of the three regions vary widely as far as extremes are concerned but show a rather surprising uniformity in total or mean annual yield. Records indicate no marked differences in the range of temperature of the water in streams over the three regions; that is, the mountain streams get just as warm in the hot summertime as those in the Piedmont or Tidewater. This is interesting and at variance with the popular notion that the mountain streams are cool in the summer, those in the Piedmont warmer and those in the coastal plain warmer yet. Actually, it has been found that the Tidewater creeks are often somewhat cooler than most of the mountain rivers. The streams with the highest annual runoff are those in southwest Virginia, such as the New River and the tributaries of the Tennessee. The streams with the lowest annual runoff are in the Shenandoah Valley, where the rainfall is lighter, although these streams have a much better low-water yield than the ones in the Piedmont or Tidewater, because of numerous large springs in that limestone valley.

Table 1 gives the annual runoff, in inches, for the calendar years 1930, 1937, 1941 and 1946 for representative rivers in each of the three main regions. An attempt has been made in Table 2 to indicate for each region the annual precipitation, runoff, evapotranspiration and resultant gain or loss to the ground water for each of those years. 1930 was a year of record drought, 1937 a very wet year with very high runoff, 1941 a severe drought year and 1946 a year of nearly normal rainfall and runoff.

These tables show the great difference in runoff in wet and dry years, ranging from 4 to 27 in. per year. It will also be noted that evapotranspiration consumes as much as 80 per cent of the precipitation in an exceptionally dry year and as much as 50 per cent in a very wet year.

Control and Conservation

There is little that can be done to change or control the 80–50 per cent evapotranspiration factor. To maintain the necessary vegetative cover, such as forests, grasslands and farm crops, it will be necessary to work with the residual 20–50 per cent of precipitation in order to conserve or increase the usable supply of surface or ground water. The most effective method, in the author's opinion, is the creation of numerous storage reservoirs widely distributed over the state at locations where there will be little interference with other uses of land. Usually very little good farm land will need to be inundated. The reservoirs will store the winter and spring runoff and make possible greatly increased supplies during the normally low runoff months of July to October.

Virginia is lacking in adequate storage reservoirs and lakes, while the demand for water for municipal and industrial use is increasing steadily. Generally speaking, no industry and few towns acting independently can build the necessary dam and reservoir and the accompanying pipelines. Therefore, there is a real necessity for regional water districts, or perhaps a statewide water authority, to make possible the financing and construction of these water projects. Any such activity would have to be authorized by the state legislature, and much careful thought and preparation should precede action by the Assembly.

Preliminary Directory of Consultants

THIS directory is a preliminary form of a listing intended as a regular feature in future issues of the A.W.W.A. *Membership Directory.* It is based on the declarations of those returning a questionnaire sent to all Association members. Because most of these questionnaires were returned in the last quarter of 1948, opening the possibility that isolated entries may now be inaccurate, and because omissions and errors are inevitable in any voluntarily executed questionnaire, the list should be considered tentative only. As many engineers failed to return questionnaires, the list is presumably far from complete. It is hoped that the stimulation provided by its publication will prompt consultants to repair most of the inadequacies in their own listings as well as in the general form and content of the directory, about which suggestions will be welcomed.

All A.W.W.A. members who claimed consulting activity in one of several branches of activity, and who listed some clients by whom they had recently been retained, have been included in the directory. None of these references has been investigated by the Association, however.

Individuals are cross-referenced to the firms with which they are associated, and company names are printed in boldface type. When the individual and the firm are the same, the individual's name is in boldface. Listings are geographic by states, and an asterisk preceding a name indicates that the individual or at least one member of the firm so distinguished is a registered professional engineer in the state under which the listing appears. Permanent branch offices have been listed only when the complete address has been supplied, and there has been included a parenthetical reference to the state in which the main office is located.

The italic letters following the address of a firm indicate the type of work done, in accordance with the key given below. All the activities denoted by the code letter are not necessarily performed by each firm so designated, however, as it has not proved practicable to break down the listings to distinguish specialization or limited activity within the various major fields. The code should therefore be accepted, with reservations, as a general guide only. Additional activities not considered to be of primary interest to those in the water supply and closely allied fields are omitted.

Key to Symbols

A—General civil engineering, design, construction, operation or maintenance
B—Sanitary engineering, municipal and industrial water treatment, sewerage or drainage
C—Appraisal, valuation or inspection
D—Chemistry, chemical engineering or bacteriology
E—Geology or ground water
F—Hydrology
G—Hydraulics, distribution system studies
H—Irrigation
J—Electrical engineering
K—Mechanical engineering
L—Accounting
*—Registered as a professional engineer in the state under which the listing appears

ALABAMA

*__Crockett, Vernon P., Engrs.,__ State National Bank Bldg., Sheffield *ABCFG*

*Hendon, Harry H.; *see* Polk, Powell & Hendon

*__Kenan, R. L., & Assoc.,__ Bell Bldg., Montgomery *ABCEG*

*__Polk, Powell & Hendon,__ Chamber of Commerce Bldg., Birmingham *AB*

ARKANSAS

Dickinson & White, *W. Dewoody Dickinson, 115 N. Spring St., Little Rock *ABCD*

Van Trump Testing Lab. (of Ill.), Roderick Van Trump, 219 Terminal Warehouse Bldg., Little Rock *ABCD*

ARIZONA

*__Leeds, Hill & Jewett__ (of Calif.), 742 Security Bldg., Phoenix *AG*

CALIFORNIA

*__Adams & Ells,__ 306 S. Peck Rd., El Monte *ABG*

Alcorn, James Dunn, 845 El Centro St., South Pasadena *ABG*

*Alderman, Frank E.; *see* Holmes & Narver

*Banks, Harvey O.; *see* Conkling, Harold

*__Blakeley, Loren E.,__ Association Lab., 1815 W. Chapman Ave., Orange *ABEH*

*__Breitkreutz, Emil W.,__ 1404 Wilson Ave., San Marino 9 *ACG*

*__Brown & Caldwell,__ 233 Sansome St., San Francisco 4 *ABDEG*

*Caldwell, David H.; *see* Brown & Caldwell

*__Clark, Everett L.,__ 807 Central Bldg., 108 W. 6th St., Los Angeles 14 *ABCEFGHL*

*__Conkling, Harold,__ 108 W. 6th St., Los Angeles 14 *ABCDEFGH*

Cook Research Labs., *Lawrence H. Cook, 950 Crane St., Menlo Park *ABCDEGHK*

*Ells, J. C.; *see* Adams & Ells

*__Hall Labs.__ (of Pa.), 200 Davis St., San Francisco 11 *BD*

*Hill, Raymond A.; *see* Leeds, Hill & Jewett

*__Holmes & Narver,__ 824 S. Figueroa St., Los Angeles 14 *ABCFG*

*__Hyde, Charles Gilman,__ 2495 Shattuck Ave., Berkeley 4 *ABEFG*

*__Jessup, Albert H.,__ 224 N. Segovia Ave., San Gabriel *B*

*Larson, Linne C.; *see* Taylor & Taylor

*__Lee, Charles H.,__ 58 Sutter St., San Francisco 4 *ABEFH*

*__Leeds, Hill & Jewett,__ 601 W. 5th St., Los Angeles 13 *AG*

*__Montgomery & Pomeroy,__ 660 S. Fair Oaks Ave., Pasadena 2 *BD*

*Morrow, Orville E.; *see* Hall Labs.

*Norgaard, John T., *see* Brown & Caldwell

*Plotkin, Sheldon N.; *see* Westcott, Ralph M., Co.

*Pomeroy, Richard; *see* Montgomery & Pomeroy

*__Taylor & Taylor,__ 725 S. Spring St., Los Angeles 14 *ABCEFGH*

*__Westcott, Ralph M., Co.,__ 1700 S. Main St., Los Angeles 15 *BD*

*__Wilson, Carl,__ 124 W. 6th St., Los Angeles 14 *BD*

COLORADO

*Howe, Benjamin V., *see* Ripple & Howe

*__Moore, Theodore L.,__ Anvil Points No. 1, Rifle *ABG*

Ripple & Howe, *Oliver J. Ripple, 426 Cooper Bldg., Denver 2 *ABEFGH*

*__Runyan, Damon,__ Longmont National Bank Bldg., Longmont *ABH*

CONNECTICUT

*__Bowe, Albertson & Assoc.__ (of N.Y.), 2082 Kings Highway, Fairfield *ABC*

*__Leffler, William S.,__ Engrs. Associated, 20 Woodland Dr., Noroton *CH*

*__Riordan, John E.,__ Valley Rd., New Canaan *BD*

*Rudd, E. Irvine; *see* Leffler, William S.

DISTRICT OF COLUMBIA

Gilbert Assoc. (of Pa.), 1432 K St. N.W., Washington *ABCDEGJKL*

FLORIDA

Black Labs., *A. P. Black, 968 S. Oak St., Gainesville *ABDEF*

*__Connell, Maurice H., & Assoc.,__ 200 Langford Bldg., Miami 32 *ABHJK*

*Gillespie, Wylie W.; *see* Smith & Gillespie

Nutting, H. C., Co. (of Ohio), 1010 N.W. 20th St., Miami 37 *G*

*Parks, Walter J., Jr.; *see* Reynolds, Smith & Hills

*__Reynolds, Smith & Hills,__ 227 Park St., Jacksonville *ABCEFGJK*

*Richheimer, Charles E.; *see* Reynolds, Smith & Hills

*__Russell & Axon__ (of Mo.), Box 1431, Daytona Beach *ABCFGHJK*

Smith & Gillespie, *W. Austin Smith, Box 1048, Jacksonville 1 *ABCEGJK*

*Williamson, A. E., Jr.; *see* Russell & Axon

GEORGIA

*Henson, James O., Jr.; *see* Patchen & Zimmerman
***Patchen & Zimmerman,** Daniel Field Airport, Augusta *ABCFGJK*
*Zimmerman, H. F.; *see* Patchen & Zimmerman

IDAHO

***Briggs, Raymond J., & Assoc.,** Briggs Engineer Bldg., 619 Grove St., Boise *ABCEGH*

ILLINOIS

***Alvord, Burdick & Howson,** 20 N. Wacker Dr., Chicago *ABCEFGK*
***Baxter, Nelson & Woodman,** Crystal Lake *ABCEG*
*Burdick, Charles B.; *see* Alvord, Burdick & Howson
Caldwell Eng. Co., *H. L. Caldwell, 803 W. College Ave., Jacksonville *ABG*
***Casler & Stapleton,** 313 W. State St., Jacksonville *ABGJ*
***Chlorination Specialists,** 11131 S. Michigan Ave., Chicago 28 *B*
*Clarke, Samuel M.; *see* Greeley & Hansen
***Consoer, Townsend & Assoc.,** Arthur W. Consoer, 351 E. Ohio St., Chicago 11 *ABCEFG*
Crawford, Murphy & Tilly, *L. K. Crawford, 400½ E. Adams St., Springfield *AB*
***Deuchler, Walter E., Co.,** 63 S. La Salle St., Aurora *ABCEGJ*
Erickson Chemical Co., E. T. Erickson, 619 N. Michigan Ave., Chicago 11 *BD*
***Fletcher, E. N.,** Municipal Bldg., Des Plaines *ABEG*
***Francis Eng. Co.** (of Mich.), 218 Cutler Bldg., Rockford *ABCEFGHJK*
*Fulkman, John A.; *see* Consoer, Townsend & Assoc.
***Gamet, Merrill B.,** Northwestern Technological Inst., Evanston *ABG*
Greeley and Hansen, *Samuel A. Greeley, 220 S. State St., Chicago 4 *ABCEG*
*Hill, Kenneth V.; *see* Greeley & Hansen
*Howson, Louis R.; *see* Alvord, Burdick & Howson
Hyatt, Chauncey A., 5555 Sheridan Rd., Chicago *B*
*Langdon, Paul E.; *see* Greeley & Hansen
*Nelson, Carlton L., Jr.; *see* Baxter, Nelson & Woodman
*Niles, Thomas M.; *see* Greeley & Hansen
Pappmeier Eng. Co., *Louis S. Pappmeier, 404 Hill Arcade, Galesburg *AB*
*Schmid, T.; *see* Chlorination Specialists
*Stapleton, Kenneth K.; *see* Casler & Stapleton
***Van Trump Testing Lab.,** 329 S. Wood St., Chicago *ABCD*
***Woltmann, J. J.,** 314 Unity Bldg., Bloomington, *ABCE*

INDIANA

***Ammerman, Davis & Stout,** 912–923 K. of P. Bldg., Indianapolis *BDJK*
Couch & Kulin, *L. I. Couch, 224 Mansur Bldg., 312 E. Washington St., Indianapolis 4 *ABEG*
*Davis, Telford Ross; *see* Ammerman, Davis & Stout
*Fulmer, Frank E.; *see* Williams, Clyde E., & Assoc.
***Hurd, Charles H.,** 333 N. Pennsylvania St., Indianapolis 4 *ADEG*
*Kulin, Harvey J.; *see* Couch & Kulin
***Leonard, O. M., & Assoc.,** 232 Franklin St., Michigan City *ABCG*
***Phelps, Boyd E., Inc.,** 232 Franklin St., Michigan City; *also* 835 K. of P. Bldg., Indianapolis *ABCGK*
***Steeg, Henry B., & Assoc.,** 2331 N. Meridian St., Indianapolis 8 *B*
***Williams, Clyde E., & Assoc.,** 312 West Colfax Ave., South Bend 1 *AB*
***Wilson, J. B.,** 10 W. Ohio St., Indianapolis 4 *B*

IOWA

***Green, Howard R., Co.,** Bever Bldg., Cedar Rapids *ABCEJK*
***Hinman, Jack J., Jr.,** 121 Melrose Ave., Iowa City *ABCD*
Patera Engineering, *Edward L. Patera, 625 Royal Union Bldg., Des Moines *ABCEFGJK*

KANSAS

***Brink-Dunwoody-Cooper,** 1½ E. Madison, Iola *ABGJ*
***Culp, Russell L.,** Garnett *AB*
*Dunwoody, G. A.; *see* Brink-Dunwoody-Cooper
Ediger Eng. Co., *O. O. Ediger, 142 Administration Bldg., Wichita Municipal Airport, Wichita *AB*
***Hunter, H. R.,** 105 W. English St., Wichita 2 *ABCGJ*
***Rector, K. E.,** 538 New England Bldg., Topeka *AB*
***Servis & Van Doren,** 106 E. 8th, Hays *ABCEFG*
***Svaty, Karl J.,** 504 N. 3rd St., Hiawatha *AC*
*Van Doren, L. M.; *see* Servis & Van Doren
Wilson & Co., *Murray A. Wilson, 223 N. Santa Fe, Salina *ABCEJ*

KENTUCKY

Bell, Howard K., *Grant S. Bell, 553 Limestone St., Lexington 45 *ABCEG*
***Forbes, H. de B., & Son,** Box 363, Richmond *AB*
*Latham, James K.; *see* Bell, Howard K.
***Mason, Clyde P.,** 507 Lafayette Ave., Lexington *AB*
***Miller, Maurice L.,** 400–05 McDowell Bldg., Louisville *ABCEFG*
***Rice, W. H.,** Morehead *ABC*
***Watkins, J. Stephen,** 145 E. High St., Lexington *ABCG*

LOUISIANA

***Barnard & Burk,** Triad Bldg., Baton Rouge *ABJK*
*Burk, Jack S.; *see* Barnard & Burk
***Macdonald, Frank W.,** School of Civ. Eng., Tulane Univ., New Orleans *ABFG*
***Mentz, Henry A.,** 500 W. Morris St., Hammond *ABCJK*

MAINE

***Clark, Horace L.,** 14 Lebanon St., Sanford *ACEG*

MARYLAND

***Geyer, John C.,** Johns Hopkins Univ., Baltimore 18 *BEF*
***Stephens, George William, Jr., & Assoc.,** 5 McCurdy Ave., Towson 4 *AB*
Whitman, Requardt & Assoc., *Ezra B. Whitman, 1304 St. Paul St., Baltimore 2 *ABCFGJK*
***Wolman, Abel,** Whitehead Hall, Johns Hopkins Univ., Homewood, Baltimore 18 *ABEFG*

MASSACHUSETTS

*Bogren, George G.; *see* Weston & Sampson
Camp, Dresser & McKee, *Thomas R. Camp, 6 Beacon St., Boston 8 *ABCEFG*
*Howard, Edwin M.; *see* Whitman & Howard
*Howard, Paul F.; *see* Whitman & Howard
Lauman, C. W., & Co. (of N.Y.), 274 Franklin St., Boston *EH*
Sampson, George A.; *see* Weston & Sampson
***Weston & Sampson,** 14 Beacon St., Boston 8 *ABCDEG*
***Whitman & Howard,** 89 Broad St., Boston 10 *ABCEFG*

MICHIGAN

***Consoer, Townsend & Assoc.** (of Ill.), 557 Paw Paw Ave., Benton Harbor *ABCEFG*
***Drury, McNamee & Porter,** 103 E. Washington St., Ann Arbor *ABCEG*
Francis Eng. Co., *George W. Francis, 303–04 Eddy Bldg., Saginaw; *also* 1019 Ludington St., Johnson Bldg., Escanaba *ABCEFGHJK*
***Hamilton-Weeber,** 354–56 Houseman Bldg., Grand Rapids 2 *B*
*Hirn, W. C.; *see* Pate & Hirn
Hubbell, Roth & Clark, *George Edgar *ABG*
*McNamee, Robert L.; *see* Drury, McNamee & Porter
***Orr, Edwin M.,** 402 Calvin Theatre Bldg., 22148 Michigan Ave., Dearborn *AB*
***Pate & Hirn,** 532 Michigan Bldg., Detroit 26 *ABG*
*Ward, A. Edward; *see* Hamilton-Weeber
Williams & Works, *W. B. Williams, Court House, Grand Rapids *AB*

MINNESOTA

*Duvall, Arnot J.; *see* Toltz, King & Day
Hitchcock & Estabrook, 521 Sexton Bldg., Minneapolis *ABCGJK*
***Lane, L. E.,** Masonic Temple, Willmar *ABCG*
Lee, Lester D.; *see* Hitchcock & Estabrook
Pfeifer & Shultz, 702 Wesley Temple Bldg., Minneapolis 4 *ABG*
***Rynda, Joseph T., Jr.,** Box 304, Montgomery *ABEGJK*
Seidel, Harris Forrest; *see* Pfeifer & Shultz
***Toltz, King & Day,** 1509 Pioneer Bldg., St. Paul 1 *ABCFGJK*

MISSISSIPPI

Moser, C. R., Engineering Co., *Cecil Ramsey Moser, 603 First Federal Savings & Loan Bldg., Jackson *ABG*

MISSOURI

*Baldwin, Robert L.; *see* Burns & McDonnell Eng. Co.
***Black & Veatch,** Ernest B. Black, 4706 Broadway, Kansas City 2 *ABCD*
***Burns & McDonnell Eng. Co.,** Box 7088, Country Club Sta., Kansas City 2 *ABCEFGJK*
Dodd, C. I.; *see* Black & Veatch
Farmer, E. A.; *see* Black & Veatch
*Filby, Ellsworth L.; *see* Black & Veatch
***Fulton, Edward A.,** 3209 Brown Rd., St. Louis *ABCFG*
***Haskins, Charles A.,** 800 Finance Bldg., 1009 Baltimore Ave., Kansas City *ABCEFG*

***Horner & Shifrin,** 803 Shell Bldg., St. Louis 3 *ABCEFG*
*Jens, Stifel W.; *see* Horner & Shifrin
***Kirkwood, A. C., & Assoc.,** 123 Wirthman Bldg., Kansas City 3 *ABCGJK*
Lawrence, R. E.; *see* Black & Veatch
Learned, Albert P.; *see* Black & Veatch
*Lischer, Vance C.; *see* Horner & Schifrin
*Mathews, C. Kelsey; *see* Burns & McDonnell Eng. Co.
Patterson, William L.; *see* Black & Veatch
***Russell & Axon,** 408 Olive St., St. Louis 2 *ABCFGHJK*
Samuel, Thomas D., III; *see* Black & Veatch
Scott, Guy R.; *see* Black & Veatch
Veatch, N. T.; *see* Black & Veatch
*Wenger, F. E.; *see* Russell & Axon
Woodson, Riley D.; *see* Black & Veatch

MONTANA

Morrison Engineering Co., *John H. Morrison, Civic Center, Helena *AB*
***Wenzel, William J.,** 409 First Ave. S.W., Great Falls *ABG*

NEBRASKA

*Cramer, John W.; *see* Fulton & Cramer
***Fulton & Cramer,** 922 Trust Bldg., Lincoln *ABCJ*
***Grupe, Edgar Y.,** Route 2, E. Overland Drive, Scottsbluff; *also* Merchants National Bank Bldg., Omaha *ABCGH*
***Hoskins, Harold, & Assoc.,** 231 N. 11th St., Lincoln *ABCJ*
***Price, Donald D.,** 1827 S. 26th St., Lincoln *B*

NEW JERSEY

***Harley, F. E.,** Fair Lawn Radburn Trust Co. Bldg., Fair Lawn *ABCEG*
Jacoby, McGrayne & Co., *Gordon C. Jacoby, 195 Van Houten St., Paterson 1 *A*
***Norcom, George D.,** Box 229, Conover Lane, Red Bank *BCD*

NEW MEXICO

***Wilson & Co.** (of Kan.), 219 W. Gold, Albuquerque *ABCEJ*

NEW YORK

***Asketh, Jordan S.,** 33 W. 42nd St., New York 18 *AEG*
***Barker & Wheeler,** 36 State St., Albany 7; *also* 11 Park Place, New York 7 *ABCEFGJ*
Blum, Louis D., & Co., 110 E. 42nd St., New York 17 *L*
Bogert-Childs Eng. Assoc., *Clinton L. Bogert, 624 Madison Ave., New York 22 *ABEG*
***Bowe, Albertson & Assoc.,** Thomas F. Bowe, 110 William St., New York 7 *ABC*
***Bull & Roberts,** 117 Liberty St., New York 6 *B*
***Caird, James M.,** Cannon Bldg., Troy *BD*
***Eliassen, Rolf,** College of Eng., New York Univ., New York 53 *AB*
*Emerson, Charles A.; *see* Havens & Emerson
Gilbert Assoc. (of Pa.), 61 Broadway, New York *ABCDEGJKL*
Haberer, James H., 108 Lynch Ave., Utica *BCDE*
***Havens & Emerson** (of Ohio), Woolworth Bldg., New York 7 *ABCDFG*
*Hazen, Richard; *see* Pirnie, Malcolm, Engrs.
***Holmes, O'Brien & Gere,** 204 E. Jefferson St., Syracuse *B*
Ingram, William T., Prof. of Pub. Health Eng., New York Univ., 20 Pt. Crescent, Malba *B*
***Irish, J. Wilbur,** 906 South St., Peekskill *AB*
Jacobson, Alvin R., San. Eng. Lab., College of Eng., New York Univ., University Heights, New York 53 *ABD*
Lauman, C. W., & Co., 50 Church St., New York 7; *also* Box 341, Hicksville, L.I. *EH*
Lauman, H. E.; *see* Lauman, C. W., & Co.
Leggette, R. M., 551-5th Ave., New York 17 *EF*
***Martin, Edward J., Jr.,** 21 N. Broadway, Tarrytown *ABCGK*
National Brewers' Academy & Consulting Bureau, 315-4th Ave., New York 10 *BD*
***Pirnie, Malcolm, Engrs.,** 25 W. 43rd St., New York 18 *ABEFG*
*Purdy, Alvin C.; *see* Bull & Roberts
***Stearns, Donald E.,** 2400 Euclid Ave., Syracuse 3 *ABCEFG*
*Tanner, John R.; *see* Holmes, O'Brien & Gere
***Taylor, Henry W.,** 11 Park Place, New York 7 *ABCG*
*Wheeler, Robert C.; *see* Barker & Wheeler
Zadigan, Ruben; *see* National Brewers' Academy & Consulting Bureau

NORTH CAROLINA

***Baity, Herman G.,** Box 899, Chapel Hill *ABF*
Colburn & Weiss, *Burnam S. Colburn Jr., 803 Jackson Bldg., Asheville *ABG*

*Davis, P. D.; *see* Piatt & Davis
***Dickson, W. K., & Co.,** 404½ S. Tryon St., Charlotte *ABC*
***Freeman, William F., Engrs.,** 116½ E. Commerce St., High Point *ABCEGJ*
***Pease, J. N., & Co.,** 119½ E. 5th St., Charlotte *ABG*
Peirson & Whitman, *Nat D. Peirson, Security Bank Bldg., Raleigh *ABCEGJK*
Piatt & Davis, *William M. Piatt, 1205 Corcoran St. Bldg., Durham *ABCDEFG JK*
*Rawlins, George S.; *see* Pease, J. N., & Co.
Watson & Hart, *John D. Watson, 1001 E. Bessemer Ave., Greensboro *ACEFGJK*

NORTH DAKOTA

***Veigel, L. W.,** Box 466, Dickinson *ABE*

OHIO

*Bare, Ben K.; *see* Burgess & Niple
***Barnes, George E.,** Case Inst. of Technology, Cleveland 6 *ABEG*
*Bonham, H. E.; *see* Uhlmann, Paul A., & Assoc.
***Burgess & Niple,** 584 E. Broad St., Columbus *ABCEFG*
***Columbus Water & Chemical Testing Lab.,** 58 Olentangy St., Columbus 2 *BD*
*Downing, Spencer D.; *see* Jones & Henry
Finkbeiner, Pettis & Strout, *Carleton S. Finkbeiner, 518 Jefferson Ave., Toledo *ABG*
*Fuller, Raymond H.; *see* Burgess & Niple
*Hatch, B. F.; *see* Burgess & Niple
***Havens & Emerson,** Leader Bldg., Cleveland 14 *ABCDFG*
*Henry, T. B.; *see* Jones & Henry
***Jones & Henry,** 821 Security Bldg., Toledo; *also* 326½ W. Federal St., Youngstown *ABCEG*
***MacDowell, Rollin F.,** 401 Chester-Twelfth Bldg., Cleveland 14 *AB*
*McGill, R. D.; *see* Nutting, H. C., Co.
*McIntyre, F. J.; *see* Columbus Water & Chemical Testing Lab.
***Nutting, H. C., Co.,** 4120 Airport Rd., Cincinnati 26 *G*
***Stilson, Alden E., & Assoc.,** 209 S. High St., Columbus *ABCEFGK*
*Tatlock, Myron W.; *see* Woolpert, Ralph L., Co.
***Uhlmann, Paul A., & Assoc.,** 1441 N. High St., Columbus 2 *ABCFG*
***Wertz, Emerson D., & Assoc.,** 116½ E. High St., Bryan *AB*
***Woolpert, Ralph L., Co.,** 360 W. First St., Dayton *AB*

OKLAHOMA

***Bretz, C. E.,** 612 Commerce Exchange Bldg., Oklahoma City *ABG*
***Flanders, Graves & Assoc.,** 210 Admiral Rd., Stillwater *ABFG*
*Graves, Quintin B.; *see* Flanders, Graves & Assoc.
***Holway, W. R., & Assoc.,** 302 E. 18th St., Tulsa 5; *also* City Hall, Vinita; *and* 11 S. Mill St., Pryor *ABFGJ*
*Holway, William N.; *see* Holway, W. R., & Assoc.
***Toler, George G., Eng. Co.,** Box 1137, Ada *AB*

OREGON

Charlton Labs., David B. Charlton, 2340 S.W. Jefferson St., Portland *BD*
***Corey, R. H.,** 421 Corbett Bldg., Portland *ABC*
***Cunningham & Assoc.,** 1112 Spalding Bldg., Portland 4 *ABEG*
*Green, Carl E.; *see* Cunningham & Assoc.
***Smithson, Thomas,** Route 2, Box 277, Beaverton *ABG*
***Stevens & Koon,** 1204 Spalding Bldg., Portland 4 *ABEFGH*
*Thompson, H. Loren; *see* Stevens & Koon

PENNSYLVANIA

***Albright & Friel,** 1528 Walnut St., Philadelphia 2 *ABCFG*
Betz, John D.; *see* Betz, W. H. & L. D.
Betz, W. H. & L. D., *L. Drew Betz, Gillingham & Worth Sts., Philadelphia 24 *ABD*
Bradford Labs., 137 Main St., Bradford *ABC*
*Campbell, John T.; *see* Chester Engrs.
***Chester Engrs.,** 210 E. Park Way, Pittsburgh 12 *ABCDEFGJ*
Columbia, J. Z., R.D. No. 2, Burgettstown *BD*
***Corson, Oscar,** 902 Highland Ave., Ambler *AB*
*Davis, Daniel E.; *see* Chester Engrs.
Ellenberger, A. R.; *see* Bradford Labs.
*Friel, Francis S.; *see* Albright & Friel
Gannett Fleming Corddry & Carpenter, *Farley Gannett, 600 N. 2nd St., Harrisburg *ABCEFGJKL*
***Gilbert Assoc.,** 412 Washington St., Reading; *also* Architects Bldg., Philadelphia *ABCDEGJKL*
***Hall Labs.,** 323-4th Ave., Pittsburgh 22 *BD*
*Hauck, Charles F.; *see* Hall Labs.
***Haydock, Charles,** 311 Commercial Trust Bldg., Philadelphia 2 *ABCE*

*__Kerr, S. Logan, & Co.__, 1528 Walnut St., Philadelphia 2 *ABDGK*

***Knowles, Morris,** 1312 Park Bldg., Pittsburgh *ABCEFG*

Laboon & Bankson, *John F. Laboon, 1116 Berger Bldg., Pittsburgh 19 *ABCEG*

*Mansfield, M. G.; *see* Knowles, Morris

***Mebus, George B.,** 112 S. Easton Rd., Glenside *ABC*

Priester, Max U.; *see* Betz, W. H. & L. D.

***Rice, John M.,** Century Bldg., Pittsburgh 22 *ABCEFGK*

***Sheen, Robert T.,** 1300 E. Mermaid Ave., Philadelphia 18 *ABD*

*Simpson, R. W.; *see* Gilbert Assoc.

Stiemke, Robert E., Dept. of Civ. Eng., Pennsylvania State College, State College *ABG*

SOUTH CAROLINA

Barber, Keels & Assoc., *B. P. Barber, Box 1116, Columbia *ABCEGJ*

*Furman, Thomas deS.; *see* Quattlebaum Eng. Co.

***Quattlebaum Eng. Co.,** Johnston *AB*

SOUTH DAKOTA

*McWayne, Albert; *see* Perkins & McWayne

***Perkins & McWayne,** 320 Paulton Bldg., Sioux Falls *AB*

TENNESSEE

***Barnard & Burk** (of La.), Chattanooga Bank Bldg., Chattanooga *ABJK*

***Parker, J. Sanders,** 816-8th Ave. S., Nashville 4 *ABCEFG*

Patchen & Zimmerman (of Ga.), Box 516, Oak Ridge *ABCFGJK*

Polk, Powell & Hendon (of Ala.), Cotton States Bldg., Nashville *AB*

***Schmidt, L. A., Jr.,** Chattanooga Federal Bank Bldg., 817 Broad St., Chattanooga 2 *AFG*

***Turner, W. W., Co.,** 206½ Union St., Nashville 3 *ABCK*

TEXAS

***Castella, William F.,** 1615 Transit Tower, San Antonio *ABEG*

*Clark, S. C.; *see* Sigler, Clark & Winston

***Classen, Ashley G., & Assoc.,** 504 N. Kansas St., El Paso *ABCEGJ*

*Cooper, S. C.; *see* Parkhill & Cooper

***Dannenbaum, J. B.,** 3940 Main St., Houston 2 *ABEG*

Franklin, Louis, 6605 Belmont, Houston 5 *E*

Freese & Nichols, *Simon W. Freese, 407 Danciger Bldg., Fort Worth *ABCEFG*

***Freese, Nichols & Turner,** 2111 National Standard Bldg., Houston *ABCEFGHJK*

Garrett Eng. Co., *M. Truett Garrett Sr., 1806 Milan St., Houston 3 *ABCGJK*

***Gilbert Assoc.** (of Pa.), 708 Lamar St., Houston *ABCDEGJKL*

Hatfield Eng. Co., *C. R. Hatfield, 211 Barfield Bldg., Amarillo *ABG*

***Helland, H. R. F.,** 302 Frost National Bank Bldg., San Antonio 5 *ABCG*

***Hunter, Homer A.,** 6403 Bob-O-Link Drive, Dallas 14 *ABEG*

*Martin, H. Fred; *see* Garrett Eng. Co.

***Montgomery, Julian, Cons. Engrs.,** 602 West Ave., Austin *ABCEFGH*

***Parkhill & Cooper,** 1006–14th St., Lubbock *ABCEFG*

Powell & Powell, *William Llewellyn Powell, 501 Thomas Bldg., Dallas *ABCFG*

***Roberts, H. N., & Assoc.,** 1310 Ave. Q, Lubbock *ABCEFGJ*

***Rose, Nicholas A.,** 1309 Anita Ave., Houston 4 *E*

***Sigler, Clark & Winston,** Box 428, Weslaco *ABCEGHJ*

***Turner, Marvin, Engrs.,** Nalle Bldg. Annex, Austin *ABCJ*

*Turner, N. P.; *see* Freese, Nichols & Turner

*Williams, G. D.; *see* Montgomery, Julian

VIRGINIA

Bardwell, Robert C., 2408 Rosewood Ave., Richmond *B*

***Froehling & Robertson,** 814 W. Cary St., Richmond *ABCDEK*

Mattern and Mattern, *Edwin K. Mattern, 118-A Campbell Ave. S.W., Roanoke *ABC*

*Weaver, Julian M.; *see* Froehling & Robertson

WASHINGTON

***General Eng. Co.,** 725 Central Bldg., Seattle 4 *ABCGHJK*

***Griffin, DeWitt C., & Assoc.,** 717 Lloyd Bldg., Seattle 1 *ABCGHJK*

*Heath, J. Ray; *see* General Eng. Co.

*Hill, W. R.; *see* Parker & Hill

*Mannes, C. O.; *see* Griffin, DeWitt C., & Assoc.

***Parker & Hill,** 2021 Smith Tower, Seattle 4 *ABEFGH*

***Porter, L. C.,** 303–2nd & Cherry Bldg., Seattle A

***Woodward, Walter L.,** 203 Empire State Bldg., Spokane 8 *ABCH*

Worthen & Wing, *Jesse M. Worthen, 11120 Gravelly Lake Drive, Tacoma 9 *ABK*

WEST VIRGINIA

*__Kelley, W. D.,__ Chamber of Commerce Bldg., Charleston *ABCG*
*__Settle, J. E.,__ Peoples Bldg., Charleston *ABL*
Thornburg, C. I., Co., Box 1892, Huntington 17 *AB*
*__Todd, A. R.,__ Wheeling Water Works, Wheeling *B*

WISCONSIN

Davy Eng. Co., *Philip S. Davy, 502 Main St., La Crosse *ABEG*
*__Hitchcock & Estabrook__ (of Minn.), 2212 E. Linnwood Ave., Milwaukee *ABCGJK*
*__Hoganson, Lester A.,__ City Hall, Burlington *ABE*

WYOMING

*__Banner, J. T., & Assoc.,__ 4 Converse Bldg., Laramie *ABFGH*
*Goodrich, Ralph D.; *see* Banner, J. T., & Assoc.
*__Streeter, Robert L.,__ Box 2010, Casper *ABG*

CANADA

Critoph, Steen & Cave, *Dennis Critoph, 1155 W. Pender St., Vancouver, B.C. *ABK*
*__Demers, George,__ 71 St. Pierre, Quebec City, Que. *ABCGH*
*__Gore & Storrie,__ 1130 Bay St., Toronto 5, Ont. *ABG*
*__Lalonde, J. A., & Co.,__ 958 Dunlop Ave., Montreal 8, Que. *ABCEG*
Main & Rensaa, *Thomas C. Main, MacCoshan Bldg., Edmonton, Alta. *ABCEFG*
Proctor, Redfern & Laughlin, *E. M. Proctor, 11 Jordan St., Toronto, Ont. *ABCDEG*
*__Rybka, Karel R.,__ 96 Bloor St. W., Toronto, Ont. *BJK*
*Storrie, William; *see* Gore & Storrie
*__Tassie, Gilbert C.,__ 2906–32nd St., Vernon, B.C. *H*
Wightman, Carey & MacDonald, *F. C. Wightman, Amherst, N.S. *BCE*

VIRGIN ISLANDS

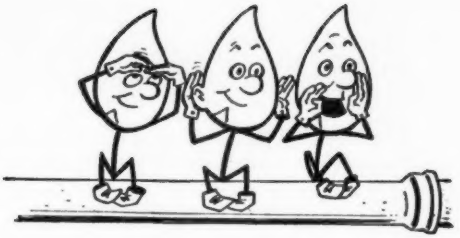
Kenan, R. L., & Assoc. (of Ala.), Charlotte Amalie, St. Thomas *ABCEG*

Notice Re:

Glossary—Water & Sewage Control Engineering

All copies of the PAPER–BOUND edition of the "Glossary" were mailed during the week of May 30.

Copies of the CLOTH–BOUND edition will be mailed approximately June 15.



Percolation and Runoff

The Chicago Conference was an unparalleled success. For the first time in Association history, more than 2,000 water workers and their wives turned out to swap technical data and to fraternize and sororize under the auspices of an A.W.W.A. program. Not only the technical sessions, but the social functions, set new records of attendance and enthusiasm. And a streamlined Thursday night banquet and ball elicited favorable comment from every quarter, as did the prime beef and music. Thus the new slate of officers which took over the 1949 reins of the Association received a spectacularly successful sendoff.

On the other hand (or, rather, palm), we read with greater courage signs of a lot of weddings scheduled for this month, word that the baseball pennant races are running true to some expert's opinion and indication that June 3 either was or could have been the most uncomfortable day on record in our life. For this is the first week in May, and our aversion to prophecy is exceeded only by our anxiety to scoop the field in reporting what might well be (or now, have been).

But turning from fancy to fact, we can at least devote some pages to the timely task of introducing our newly elected officers and directors:

President—A. P. Black, professor of chemistry at the Univ. of Florida and consulting chemical engineer. He was born in Blossom, Tex., in 1895 and received his education at Southwestern Univ., Georgetown, Tex., from which he was graduated in 1917 with an A.B. degree. Later on he managed to squeeze in a Ph.D. degree, obtained from the Univ. of Iowa in 1933.

The wide and varied career of this professor of chemistry began, oddly enough, with the post of professor of chemistry—this was at Wesley College, Tex., in 1917, and included the departmental chairmanship. A year later, with World War I waging, he joined the Army's Chemical Warfare Service, leaving it upon cessation of hostilities to become assistant chemist with the U.S. Bureau of Standards at Washington, D.C. In 1919 he

(Continued on page 2)

(Continued from page 1)

accepted a post as assistant professor of chemical engineering at the Univ. of Florida, later transferring to agricultural chemistry and, in 1923, becoming professor of chemistry, his present title.

Extra-curricular activities include the duties of contributing editor to the *Journal of Chemical Education,* which he performed from 1924 to 1940, and consulting services as chemical engineer to a number of municipalities and corporations in Florida. He is a Charter Member of the Inter-American Assn. of Sanitary Engineering, and also belongs to too many other technical and scientific societies to mention here. He joined the A.W.W.A. in 1929 and has been Director, Chairman and Secretary-Treasurer of the Florida Section, the latter for about 9 years. He has been a Director of the Water Purification Div. and Chairman of the Committee on Methods of Determining Fluorides, and is currently a member of several other Association committees, including the one revising the *Manual of Water Quality and Treatment.* He received his section's Fuller Award in 1939 and has just completed a term as national Vice-President.

Vice-President—W. Victor Weir, president of the St. Louis County Water Co. and of the Missouri Water Co. Born in Warren, Ind., in 1902, he was educated at Washington Univ. In 1923, upon receiving his B.S. degree in civil engineering, he became junior engineer with the West St. Louis Water & Light Co., predecessor to the St. Louis County Water Co., and was successively appointed engineer, assistant manager, chief engineer, superintendent, vice-president, general manager, and, in 1946, president. In the Missouri Water Co. he has progressively been superintendent, vice-president and general manager, and president. The latter company operates water systems in Lexington and Independence, Mo.

A member of the Association since 1924, Weir has been exceptionally active in section and national affairs. He was Chairman of the old Missouri Valley Section, of the Plant Management and Operating Div., and of the old Finance and Accounting Div. Currently he is General Chairman of the Committee on Organization and Administrative Policy and is a member of committees devoted to water works administration, publication review, national water policy, public relations, meters, graphical symbols and the revision of the *Manual of Water Quality and Treatment.* He received the Diven Medal in 1940, the Fuller Award in 1943, and was completing a three-year term as his section's national director when elected to the Vice-Presidency.

(Continued on page 4)

(*Continued from page 2*)

Treasurer—William W. Brush, Editor, *Water Works Engineering.* Brush was born in Orange, N. J., in 1874 and was educated at New York Univ., from which he received B.S., C.E., and M.S. degrees. He served as engineer with the Brooklyn Water Dept. from 1894 to 1907, transferring to the New York Board of Water Supply in the latter year. In 1927 he was appointed chief engineer, and served in that capacity until 1934. In that year he began his present affiliation with the Case-Shepperd-Mann Publishing Corp. and *Water Works Engineering.*

His reelection as Treasurer continues an unbroken record of over a quarter-century of high office in the Association, for, except for a two-year interval in 1928–29 when he was successively Vice-President and President, Brush has been Treasurer since 1922. In that time also he has been active on many A.W.W.A. committees, and has served ex officio as a member of both the Board of Directors and its Executive Committee. He received the John M. Diven Medal in 1932 and in 1937 was made an Honorary Member.

Canadian Section—W. Elwood MacDonald, city water works engineer for Ottawa, Ont., in which city he was born and received his education. After some early experience as a surveyor and draftsman for the city of Ottawa, he was assigned to John A. and Edward S. Cole Pitometer Co., of New York, for special training in waste water surveys. In 1914, he became assistant in the firm of R. S. and W. S. Lea, engineers of Montreal, Que. The following year, while associated with the consulting firm of J. B. McRae of Ottawa, he worked on various water supply projects. The post of assistant water works engineer, which he obtained in 1916, brought him back to Ottawa public service, in which he has remained, with an interval for military service during World War I, ever since. In 1931 he was promoted to his present position in complete charge of the design, maintenance and operation of the city's water works. Among his other accomplishments is the invention, in 1919, of a self-contained electric thawing apparatus.

(*Continued on page 6*)

(*Continued from page 4*)

Indiana Section—Edward F. Kinney, district manager for the Wallace & Tiernan Co., with headquarters at Indianapolis, Ind. He was born in Syracuse, N.Y., and attended Manhattan College in New York City. In 1926 he joined the Wallace & Tiernan organization, with which he has remained ever since. He has been Vice-Chairman and Chairman of the Indiana Section. His activity in district meetings, membership building and short schools earned mention in the citation for the Fuller Award which he received in 1944, although it was primarily given for his work in time of disaster.

Iowa Section—H. F. Blomquist, superintendent and engineer of the Cedar Rapids, Iowa, water works. A native of Wisconsin, he received a C.E. degree from the Univ. of Minnesota in 1907, and spent the next three years as city engineer of New Ulm, Minn. His next post was that of city engineer and superintendent of water works at Mankato, Mich., where he served until 1917. The following year he was appointed principal assistant engineer of the St. Paul, Minn., water department, in which capacity he made a location survey and estimate of cost of a cross-country conduit from St. Paul to the Mississippi River north of Minneapolis. In 1921 he was appointed to his present post with the Cedar Rapids water works.

(*Continued on page 8*)

(Continued from page 6)

Kansas—Major C. Hagar, superintendent of the Lawrence, Kan., water department. He was born in Boonville, Mo., in 1903, and received a business college education there. He then studied metallurgy with Mrs. May B. Lindley, Oakland, Calif., metallurgist, and did special work in sanitary engineering at the Univ. of Missouri. He is now a registered professional engineer in Missouri and Kansas.

The metallurgical training was put to good use when he accepted a position operating mining properties in Mexico in 1927. Three years later he was working with the U.S. Engineers on navigation and flood control along the Missouri River. From 1937 to 1942 he was superintendent of the Boonville, Mo., water department. The next post to occupy him was that of plant engineer—and later general manager—of the Ashley Div., General Aviation Equipment Co., of Wilkes-Barre, Pa. In 1944 and 1945 he was engaged in a malaria survey in southwest Missouri for the U.S. Public Health Service, and in the latter year accepted his present position. Until his election as Director, he had been serving as Secretary-Treasurer of the Kansas Section.

Missouri Section—Melvin P. Hatcher, director of the Kansas City, Mo., water department. He has a B.S. degree in civil engineering from the Univ. of Missouri (1920) and is a licensed professional engineer in five states: Missouri, Ohio, Michigan, New York and Florida.

From 1918 to 1940, Hatcher was associated with Burns and McDonnell Engineering Co., of Kansas City, Mo., as an engineer engaged mainly in water works design and valuation and utility rate-making practice. In 1940 he began his affiliation with the Kansas City water department, at first as chief engineer and superintendent, and from 1943 to date as director. In the A.W.W.A., he has held the posts of Secretary of the old Missouri Valley Section, Chairman of the Missouri Section, and Chairman of the Plant Management Division. He has been awarded the John M. Goodell prize and the Fuller Award, both in 1948, and currently holds the post of Chairman of the Committee on Annual Reports.

(Continued on page 10)

Experienced Water Works men know it pays to use products made by RENSSELAER

...for instance SLEEVES AND VALVES FOR Tapping AND REPAIR

There are many good makes of tapping and repair equipment available today. But there's only ONE line with the name RENSSELAER behind it—and that means a lot to experienced users. It means CERTAINTY of rugged construction, no breakdowns on the job. It means LASTINGLY watertight sleeve joints with heavy lead gaskets full sleeve length. It means that bolts WON'T TURN in bottom half of Rensselaer sleeves while nuts are being tightened—a big help on the job.

And it means l-o-n-g sleeves for greater support, plus a neater job of centering the sleeve, better caulking and saving of lead, (thanks to the raised lead-rings inside). Yes, it always pays to buy under the name Rensselaer, the name backed by over 65 years of experience. Why not call in a Rensselaer Representative today?

LEADERSHIP FOR OVER 65 YEARS

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Gate Valves • Square Bottom Valves • Tapping Valves and Sleeves
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RENSSELAER VALVE COMPANY • TROY, N. Y.

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Atlanta, Bala-Cynwyd, Pa., Chicago, Denver, Haverhill, Mass., Hornell, N. Y., Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle, Waco

(*Continued from page 8*)

North Carolina—George S. Moore, superintendent of utilities at Albemarle, N.C. Born in Greenville, S.C., in 1899, Moore was reared and educated—and later became superintendent of public works—in the inappropriately named community of Leaksville, N.C. After being graduated from business college in 1919, he attended North Carolina State College and the Univ. of North Carolina, doing special engineering work. He is a licensed engineer in that state.

His tenure at Leaksville was from 1922 to 1927, after which he accepted his present post at Albemarle. He has been Vice-Chairman, Chairman and Secretary-Treasurer of his section.

Rocky Mountain Section—Dana E. Kepner, manufacturers' representative of Denver, Colo., of which city he is a native. A graduate of the Massachusetts Inst. of Technology (1921), Kepner started out as an assistant in sanitary engineering at the Harvard Univ. Engineering School. From 1922 to 1924 he served as assistant engineer in the Chicago Sanitary District, following which he returned to Colorado for a five-year term as state sanitary engineer. He left the field of public service in 1929 to accept the post of manager of the Denver Office of the Pacific States Cast Iron Pipe Co., which he held until 1932. In the following year he began his present activities as manufacturers' representative for

(*Continued on page 12*)

(Continued from page 10)

water works and sewage equipment. He has been secretary and chairman of the Rocky Mountain Sewage Works Assn., president of the Colorado Engineering Council, and secretary and chairman of his A.W.W.A. section. In 1939 he received the Fuller Award.

Southeastern Section—Henry M. Mathews, superintendent of the Thomasville, Ga., Water and Light Dept. He was born in the town of Quitman, Ga., and attended the Georgia Inst. of Technology. He began working in the Thomasville Water and Light Dept. in 1926, and in 1939 was appointed to his present post as superintendent.

Mathews is a registered professional engineer in the state of Georgia, and has been active in civic and technical organizations in that state. He was a trustee of the A.W.W.A. Southeastern Section for two years.

(Continued on page 14)


SURE! THOSE BUFFALO METERS YOU INSTALLED WHEN THE CITY WAS METERED ARE STILL RUNNING
• Many of the Buffalo-made Water Meters installed by water works up to forty years ago are still giving daily service.
Meters installed in 1949 will give even better service because of the many refinements in today's American or Niagara meters.
AMERICAN BRONZE CASE
NIAGARA GALV. IRON CASE
WATER METERS
BUFFALO METER COMPANY
2914 MAIN STREET, BUFFALO 14, N. Y.

(Continued from page 12)

Virginia Section—Howard E. Lordley, assistant director of the Richmond, Va., Dept. of Public Utilities. He obtained a B.S. degree in chemical engineering from Virginia Polytechnic Inst. in 1934 and an M.S. degree in chemistry in 1936, after postgraduate studies at the same institution. Thereupon he became plant manager of the Richmond Water Purification Plant, a post which he held until 1946, with an interval for military service from 1941 to 1945. Promotion to the position of assistant chief engineer of the Dept. of Public Utilities came in 1946, and in 1948 he was given his present title of assistant director of the department. He has been a director of his A.W.W.A. section and at present is one of the directors of the Association's Water Purification Div.

West Virginia—T. J. Blair Jr., president and director of the West Virginia Water Service Co. He was born in 1891 in Weston, W.Va., where he received his early education. Later on he attended West Virginia Wesleyan College and West Virginia Univ., receiving a B.S.C.E. degree from the latter school in 1915. He is a registered professional engineer in West Virginia. Blair has been managing water utilities since 1920, and has been a member of the Association since 1924. He is also a member of the American Society of Civil Engineers.

(Continued on page 16)

(Continued from page 14)

Wisconsin Section—William U. Gallaher, superintendent of the Pumping, Purification and Softening Plant of the Appleton, Wis., Water Dept. He received the degrees of B.S. in chemical engineering and M.S. from the Univ. of Iowa in 1921, and a Ph.D. for work in the chemistry of water, sewage and sanitation from the Univ. of Illinois in 1924. The same year he accepted an appointment as superintendent of filtration for the Highland Park, Mich., Water Works. In 1928 he became assistant state sanitary engineer in Wisconsin, and the following year was made sales engineer for the General Chemical Co. in Chicago. In 1930 he joined the Springfield, Ill., Water Works as assistant chemist. His next affiliation, in 1931, was as chief chemist with Supervising Engineers, Harrisburg, Pa. Since 1932 he has held his present post at Appleton, and since 1937 he has also been a lecturer at the Inst. of Paper Chemistry in the same city. He has been chairman of his A.W.W.A. section and been active on several Association committees. The Fuller Award was presented to him in 1943.

Manufacturer—Daniel J. Saunders, vice-president of the Permutit Co. Born in New York City in 1898, Saunders saw service during World War I with the Navy (1917–1919), and in the course of his tour of duty was sent to Stevens Inst. of Technology at Hoboken, N. J. He also attended Cooper Union in New York. In 1919 and 1920 he was a junior officer of the U. S. Shipping Board, joining the Permutit Co. in the latter year as assistant manager of sales. In 1936 he was appointed manager of industrial and municipal sales, and he became vice president in 1946. He is a member of the Engineers' Club of New York and of the Technical Assn. of the Pulp and Paper Industry (TAPPI). He has been vice president and president of the Water and Sewage Works Manufacturers Assn., and is currently a member of its Board of Governors.

Clifford L. Morgan, hydraulic and civil engineer, is now associated with Dana E. Kepner, manufacturers' representative in Colorado, Wyoming and New Mexico, with headquarters in Denver.

(Continued on page 20)

ABOUT CAST IRON PIPE!

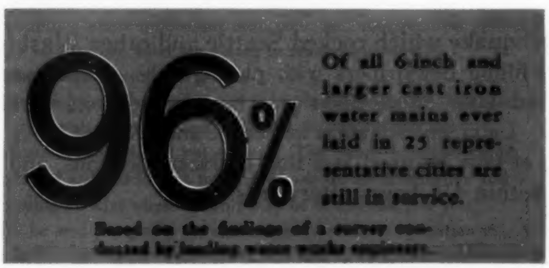
In 1849—one hundred years ago—Utica laid her first 6-inch cast iron pipe. Of all the 6-inch cast iron pipe laid from that date, 98.2% is still in service.

In the same year, Utica installed her first 12-inch cast iron pipe and 99% of all the 12-inch cast iron pipe laid from that date is still in service.

Utica is one of the cities included in the survey of "Survival and Retirement Experience with Water Works Facilities," including cast iron water mains, conducted under the auspices of the American Water Works Association, the New England Water Works Association and the Institute of Water Supply Utilities. The recently published report of the findings of the survey shows that 96% of all 6-inch and larger cast iron water mains ever laid since 1817 in 25 representative cities are still in service.

Utica's experience with cast iron water mains, therefore, while remarkable, and eminently satisfactory to her taxpayers, is not exceptional.

We shall be glad to send on request a copy of our brochure "Survival and Retirement Experience with Cast Iron Water Mains," reprinted by permission. Address Thomas F. Wolfe, Engineer, Cast Iron Pipe Research Association, 122 South Michigan Avenue, Chicago 3, Illinois.



SERVES FOR CENTURIES

(*Continued from page 16*)

"Wire-to-water efficiency" is one of those terms we've never completely understood. Now, however, thanks to the activities of Dave King, an Amish farmer of Lancaster County, Pa., our confusion has at last been dispelled. The wire involved is an ordinary pair of wire pliers; the water, underground streams; and the efficiency so great that the pliers jump right out of King's hands when several streams simultaneously exert influence upon them.

King, be it revealed, is king among the "modern" dowsers—modern by virtue of having progressed beyond the use of such primitive devices as the peach twig and the hazel branch as instruments of divination. Thus, when King recently paced over the property of the Stoystown, Pa., Water Co., he grasped his pet pliers firmly in hand and didn't consider his commission executed until he had found a spot at which they took a double jump, indicating, obviously, the presence of three underground streams. By ignoring minor "turn-down" indications and even "single jumps," King demonstrated the kind of perseverance that has promoted science to its present place in the world. Then, by following through to determine the exact depth of the well required to tap the stream, he gave evidence of the utter up-to-dateness of his methods by using the latest "tinkling ring technic," a procedure which involves suspending a gold ring on a silk thread in an empty water glass, setting the ring swinging and counting the number of times it strikes the glass. Based upon his count of 140 tinkles, King was able unhesitatingly to advise Stoystowners that their thirst would be quenched at a depth of 140 ft., so now it remains only for the water company to complete drilling operations.

And if, with our vocabulary thus fortified and our knowledge of science thus augmented, we still belabor our benefactor with irreverent doubts, it is undoubtedly attributable to the fact that we never really understood the term, "scientific method," either.

The earthquake which rocked Seattle and other Washington cities on April 13, filling newspapers with photographs of spectacular damage, apparently had little effect upon water mains, despite early reports of main breaks. Later investigation in Seattle showed that leaks were caused by loosening of pipe joints at less than a dozen locations, and that service was normal within 4½ hours afterwards.

Gustave G. Werner, Jr., partner in the firm of Malcolm Pirnie Engrs., has been awarded the Golden Cross of the Greek Phoenix Regiment by King Paul. He had spent 20 months in Greece as chief engineer for restoration of communication facilities, in connection with the program of the American Mission for Aid to Greece.

(*Continued on page 56*)


Good
to the Eye...
Good
to the Taste...

Platter Chatter

To the Editor:

I have just received my copy of the JOURNAL for April and noted your attractive cover picture and the description as given on page 330.

As you know, the Water and Sewage Works Manufacturers Assn. sponsored an "Antique Exhibit" at the A.W.W.A. Annual Conference in Chicago. For that exhibit I prepared a pictorial history of the development of water works pumping equipment which was shown through the courtesy of Allis-Chalmers. I have, therefore, delved somewhat into the history of old equipment. In the *Journal of the Franklin Institute* for October 1876 there is a sketch of the Centre Square pumping engine and small pictures of the plan and elevation of the station. These correspond exactly with the picture on the plate. Now, it is possible that the Schuylkill Station had the same architectural design—I do not know about that.

The drawing I refer to was made by Frederic Graff "from the original drawings and memoranda in my possession." Mr. Graff was a draftsman in the Philadelphia Water Works in 1799 and later became its superintendent.

GRANT M. HINKAMP

Engr., Public Works
Central Sta. & Indus. Sales Dept.
General Machinery Div.
Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.; Apr. 21, 1949

To the Editor:

I enjoyed very much seeing the blue plate special which was used on the cover of the April JOURNAL. The picture is undoubtedly a reproduction from one which hangs in my office and is dated 1801. The wagon has been shifted to the left, a carriage and two dogs have been taken out, and the two trees on the borders of the picture have been revised. Otherwise the details, including the smoke from the chimney, are the same.

This is a picture of a booster pumping station which occupied the site in Center Square now occupied by City Hall. The marble top encloses the wooden tanks referred to in Mr. Friel's paper (Dec. 1948 JOURNAL, p. 1253). The first pumping station, or what we would call the low-lift pumps, was erected on the banks of the Schuylkill at the foot of Chestnut St. The water was lifted high enough to flow by gravity through a brick-lined conduit and open canal to Center Square where pumps, installed in the station shown on the plate, lifted the water to the wooden tank in the dome above the station. We have no records of the station on the banks of the Schuylkill.

ELBERT J. TAYLOR

Chief, Bureau of Water
Dept. of Public Works
Philadelphia, Pa.; Apr. 29, 1949

Our thanks to alert readers Hinkamp and Taylor for dishing out the dope—or rather, for doping out the dish.

PROFESSIONAL SERVICES

Membership Changes

MEMBERSHIP METER
TOTAL
7439
MAY | 1 | 1949
AMERICAN WATER WORKS ASSOCIATION

NEW MEMBERS

Applications received April 1 to 30, 1949

Adams, George R., Supt. of Water & Sewage Treatment, Indiana State Reformatory, 2802 N. Dearborn St., Indianapolis, Ind. (Apr. '49)

Amherst Water Com., V. G. Fuller, Secy., 60 Church St., Amherst, N.S. (Corp. M. Apr. '49)

Andrews, John, Chemist & Supervisor of Water Purif. Plant Operation, Dept. of Public Utilities, Raleigh, N.C. (Jan. '49)

Angley, E. A., Gen Mgr., City Water Works, 109 E. Michigan Ave., Marshall, Mich. (Apr. '49)

Arruzza, Albert F., Chem. Engr. in Charge of Plant Services, American Cyanamid Co., Pearl River, N.Y. (Apr. '49) *MPR*

Badgeley, George Warren, Draftsman, Long Island Water Corp., 733 Sunrise Highway, Lynbrook, N.Y. (Apr. '49) *M*

Beard, Ralph Finney, Canada Dry Ginger Ale, Inc., Control Lab., 635 W. 54th St., New York, N.Y. (Apr. '49) *P*

Bennett, Carl Melvin, City Engr., City Hall, Colorado Springs, Colo. (Apr. '49)

Berens, Richard Conrad, Research Asst., Pennsylvania Economy League, 363 Broad St. Station, Philadelphia 2, Pa. (Apr. '49) *M*

Bixler, G. R., *see* Nichols Hills, Town of

Black, Charles E., *see* Delray Beach, City of

Brown, John L., Jr., *see* Cannon Mills Co.

Brown, Perry H., *see* Johnston Pump Co.

Burgess, Holla, Supt., Water Works, Cookeville, Tenn. (Apr. '49)

Butler, John J., Jr., Salesman, West Virginia Pulp & Paper Co., 230 Park Ave., New York 17, N.Y. (Apr. '49)

Cain, Orville Lee, Asst. Office Engr. (Area Coordinator), Brown-Pacific-Maxon, Station 1, Box 2, Guam, Guam (Apr. '49) *PR*

Callard, Edwin George, Asst. Civ. Engr., Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '49)

Cannon Mills Co., John L. Brown Jr., San. Engr., Kannapolis, N.C. (Corp. M. Apr. '49) *P*

Cardiff, R. J., Supt. of Works, Arnprior, Ont. (Apr. '49)

Cary, James G., *see* Hornell Water Dept.

Chatterjee, S., Supt. & Engr., Baranagar Kamarhatty Water Works, Baranagar, West Bengal, India (Apr. '49)

Clark, Herbert L., Supt., Water Works, Box 233, Morrisburg, Ont. (Apr. '49)

Colorado Springs, City of, C. C. Eastham, Supt., Water Div., Utilities Bldg., 18–20 S. Nevada Ave., Colorado Springs, Colo. (Corp. M. Apr. '49)

Commonwealth Eng. Co., The, Malvern J. Hiler, Exec. Vice-Pres., 1771 Springfield St., Dayton 3, Ohio (Corp. M. Apr. '49)

Compton, Henry John, Contractor, R.R. No. 2, South Haven, Mich. (Apr. '49)

Cortland Water Board, Daniel J. Houlihan, Water Supt., 23 Court St., Cortland, N.Y. (Mun. Sv. Sub. Apr. '49)

Cross, E. R., *see* Lexington Water Dept.

Davis, R. W., Supt., Water Works, Lewisburg, Tenn. (Apr. '49)

Day, Harvey A., Master Mechanic & Operator, Sunny Isles Water Co., Box 682, Hallandale, Fla. (Apr. '49)

Deakyne, J. Frank, City Mgr., City of Seaford, 208 Pine St., Seaford, Del. (Apr. '49)

Delray Beach, City of, Charles E. Black, City Mgr., City Hall, S.E. 5th Ave., Delray Beach, Fla. (Corp. M. Jan. '49)

Dow, Arthur L., City Mgr. & Supt., Board of Public Utilities, Paris, Tenn. (Apr. '49)

(*Continued on page 30*)

(Continued from page 28)

Downs, M. W., Mgr., Public Utilities Com., Meaford, Ont. (Apr. '49)

Drew, E. C., Avenal Water Supt., Coast Counties Gas & Elec. Co., 1543 Pacific Ave., Santa Cruz, Calif. (Apr. '49)

Dunbar, R. E., Pres., Ashfork Water Co., Inc., Box 858, Ashfork, Ariz. (Apr. '49)

Dunlap, A. O., Owner, Well Drilling Co., Dunedin, Fla. (Apr. '49)

Eadie, Alfred H., Mgr., Public Utilities Com., Palmerston, Ont. (Apr. '49)

Eastham, C. C., *see* Colorado Springs, City of

Edmunds, C., Mgr., Public Utility Dist., Main St., Truckee, Calif. (Apr. '49)

Elmore, Andrew P., Contractor, 1700 S. Buckeye St., Kokomo, Ind. (Apr. '49)

Escondido, City of, C. M. Reed, City Administrator, City Hall, Escondido, Calif. (Corp. M. Apr. '49)

Fuller, V. G., *see* Amherst Water Com.

Garon, Leopold, *see* Rimouski, Town of

Gifford, Henry E., Sales Repr., Mathieson Chemical Corp., 1034 Hibbler Circle, Chattanooga 4, Tenn. (Apr. '49)

Glover, C. A., Supt., Water & Sewer Depts., Lexington, Miss. (Apr. '49)

Govantes, Carlos, Student, Univ. of Havana, Calle 11, No. 451, Vedado, Havana, Cuba (Apr. '49)

Green, Ralph D., Contractor, Box 503, Vincennes, Ind. (Apr. '49)

Halter, Sam, Supt., Water Works, Seelyville, Ind. (Apr. '49)

Harrell, H. O., Water Supt., City Water Plant, El Reno, Okla. (Apr. '49) *MR*

Haskett, Robert, Jr., Water Supt., Water Works, Westfield, Ind. (Apr. '49)

Hayes, Joseph A., Sales Engr., Neptune Meter Co., 2701 Chestnut St., Camp Hill, Pa. (Apr. '49)

Helmer, Philip E., City Water Supt., Pinconning, Mich. (Apr. '49)

Herold, Henry R., Assoc. Engr., Water Dept., 323 County City Bldg., Seattle 4, Wash. (Apr. '49)

Hiler, Malvern J., *see* Commonwealth Eng. Co., The

Hornell Water Dept., James G. Cary, Supt. of Water, Hornell, N.Y. (Mun. Sv. Sub. Apr. '49)

Houlihan, Daniel J., *see* Cortland Water Board

Hutchings, R. L., Salesman, Hays Mfg. Co., 111 Dundee Drive, Syracuse, N.Y. (Apr. '49)

Johnson, Nick G., Jr. San. Engr., State Dept. of Health, 1480 S. 3rd St., Louisville, Ky. (Apr. '49)

Johnston Pump Co., Perry H. Brown, Chief Engr., 2324 E. 49th St., Los Angeles 11, Calif. (Assoc. M. Jan. '49)

Kingsbury, Francis H., *see* Massachusetts Dept. of Public Health

Lalonde, Jean Paul, Cons. Engr., Lalonde & Valois, 527 Canada Cement Bldg., Montreal, Que. (Apr. '49)

Langlais, Zachée, Cons. Engr., 105 Cote de la Montagne, Quebec, Que. (Apr. '49)

Lavoie, Edouard, Lavoie & Delisle, Civ. Engrs., 187 Racine St., Chicoutimi, Que. (Apr. '49)

Leonard, D. I., City Mgr., Municipal Bldg., Johnson City, Tenn. (Apr. '49)

Levin, Robert B., Chemist, Tripure Products Co., 652 N.W. 14th St., Miami 36, Fla. (Apr. '49)

Levy, Harold C., Asst. Civ. Engr., Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '49)

Lexington Water Dept., E. R. Cross, City Mgr., 614 N. Washington, Lexington, Neb. (Mun. Sv. Sub. Apr. '49) *MPR*

Leyenberger, Lawrence Alden, Civ. Engr., Buck, Seifert & Jost, Ind. Algodonera Bldg., Santurce, Puerto Rico (Apr. '49)

Littlefield, Thomas K., San. Engr., State Dept. of Public Health, 420—6th Ave., N., Nashville, Tenn. (Apr. '49) *PR*

Loucks, Donald A., Asst. Civ. Engr., Water Dept., 201 E. 68th St., Long Beach 5, Calif. (Apr. '49)

Marchand, Yvon, City Engr., City Hall, Sorel, Que. (Apr. '49)

Marsh, Ralph E., Supt., Rancho Mutual Water Co., Box 30, Route 1, Rolling Hills, Calif. (Apr. '49)

Massachusetts Dept. of Public Health, Div. of San. Eng., Francis H. Kingsbury, 511a State House, Boston, Mass. (Corp. M. Apr. '49) *MPR*

McClellan, Eugene W., Dist. Mgr., Homelite Corp., 841 Ellicott Sq., Buffalo, N.Y. (Apr. '49)

(Continued on page 32)

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McCormick, Robert E., City Engr., Civic Center, Great Falls, Mont. (Apr. '49) *P*

Meranda, Norman E., *see* Yellow Springs Board of Trustees of Public Affairs

Metzger, John C., Production Mgr., Worthington-Gamon Meter Co., 296 South St., Newark 5, N.J. (Apr. '49)

Miller, George, Erection Supt., Francis Hankin & Co., Ltd., Rockton, Ont. (Apr. '49)

Moilanen, Toivo E., Supt., Bryn Mawr Water Dist. 4, Box 466, Seattle 88, Wash. (Apr. '49)

Moore, Clyde N., Jr., Asst. Civ. Engr., Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '49)

Moore, Robert H., Mech. Elec. Supt., Falconbridge Nickel Mines Ltd., Falconbridge, Ont. (Apr. '49)

Murray, W. Bruce, San. Engr., Water Dept., 816 E. 19th St., Long Beach 6, Calif. (Apr. '49)

Nason, Edward McKinney, Town Engr., Bridgewater, N.S. (Apr. '49) *M*

Nebraska Inspection Bureau, E. C. Wagner, Chief Engr., 3016 Harney St., Omaha, Neb. (Corp. M. Apr. '49)

Niagara Falls Dept. of Water, Fred V. H. Piper, Director, 22 City Hall, Niagara Falls, N.Y. (Mun. Sv. Sub. Apr. '49)

Nichols Hills, Town of, G. R. Bixler, Town Clerk, 6407 Avondale Drive, Oklahoma City 6, Okla. (Mun. Sv. Sub. Apr. '49) *M*

O'Brien, John F., Sales Engr., Infilco, Inc., 60 E. 42nd St., New York, N.Y. (Apr. '49)

Oland, Carl G., Water Comrs., Sidney, Mont. (Apr. '49) *M*

Papineau, Marcel, City Engr., City Hall, Victoriaville, Que. (Apr. '49)

Parks, A. B., Secy., Nebraska Retail Plumbers Assn., 1805 Harney St., Omaha 2, Neb .(Apr. '49)

Parks, Warren W., Village Mgr. & Supt., Water Works Dept., Village of Indian Hill, Box 280A, R.R. 10, Cincinnati 27, Ohio (Apr. '49) *M*

Piper, Fred V. H., *see* Niagara Falls Dept. of Water

Port Perry, Corp. of Village of, John F. Raines, Clerk-Treas., Port Perry, Ont. (Corp. M. Apr. '49)

Prichard, George William, Prin. Engr., Black & Veatch, 4706 Broadway, Kansas City, Mo. (Apr. '49)

Pritchard, R. W., Mgr. & Supt., Water System, Morristown, Tenn. (Apr. '49)

Radelmiller, Myron, Supt., Water Dept., 3rd & Clark, Pasco, Wash. (Apr. '49)

Raines, John F., *see* Port Perry, Corp. of Village of

Randall, W. O., Neptune Meters Ltd., Lakeshore Rd., Long Branch, Ont. (Apr. '49)

Randolph, Harrison T., Asst. Elec. Engr., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Apr. '49)

Reed, C. M., *see* Escondido, City of

Reitan, H. C., Water Inspector, Northern Pacific Ry. Co., Fargo, N.D. (Apr. '49)

Rhodes, J. O., Sr., Supt., Water Works Plant, 1706 Selma Ave., Selma, Ala. (Apr. '49)

Richards, John Raymond, Chief Mech. Engr., Sanitation Constr., Virginia Eng. Co., 29th St. at James River, Newport News, Va. (Apr. '49) *P*

Riddle, Rolean Bill, Utility Supt. & City Engr., Frederick, Okla. (Apr. '49)

Rimouski, Town of, Leopold Garon, Town Mgr. & Engr., 55, de la Cathedrale, Rimouski, Que. (Corp. M. Apr. '49)

Scheuber, Carl, Supt., Water Dept., Montrose, N.Y. (Apr. '49)

Schultes, August C., Jr., A. C. Schultes & Sons, 501 Mantua Ave., Woodbury, N.J. (Apr. '49)

Sennet, Lowell E., Sales Repr., A. P. Smith Mfg. Co., 8 S. Dearborn St., Chicago 3, Ill. (Apr. '49)

Sepede, Frank J., City Comptroller, City Hall, N. Miami Beach, Fla. (Apr. '49)

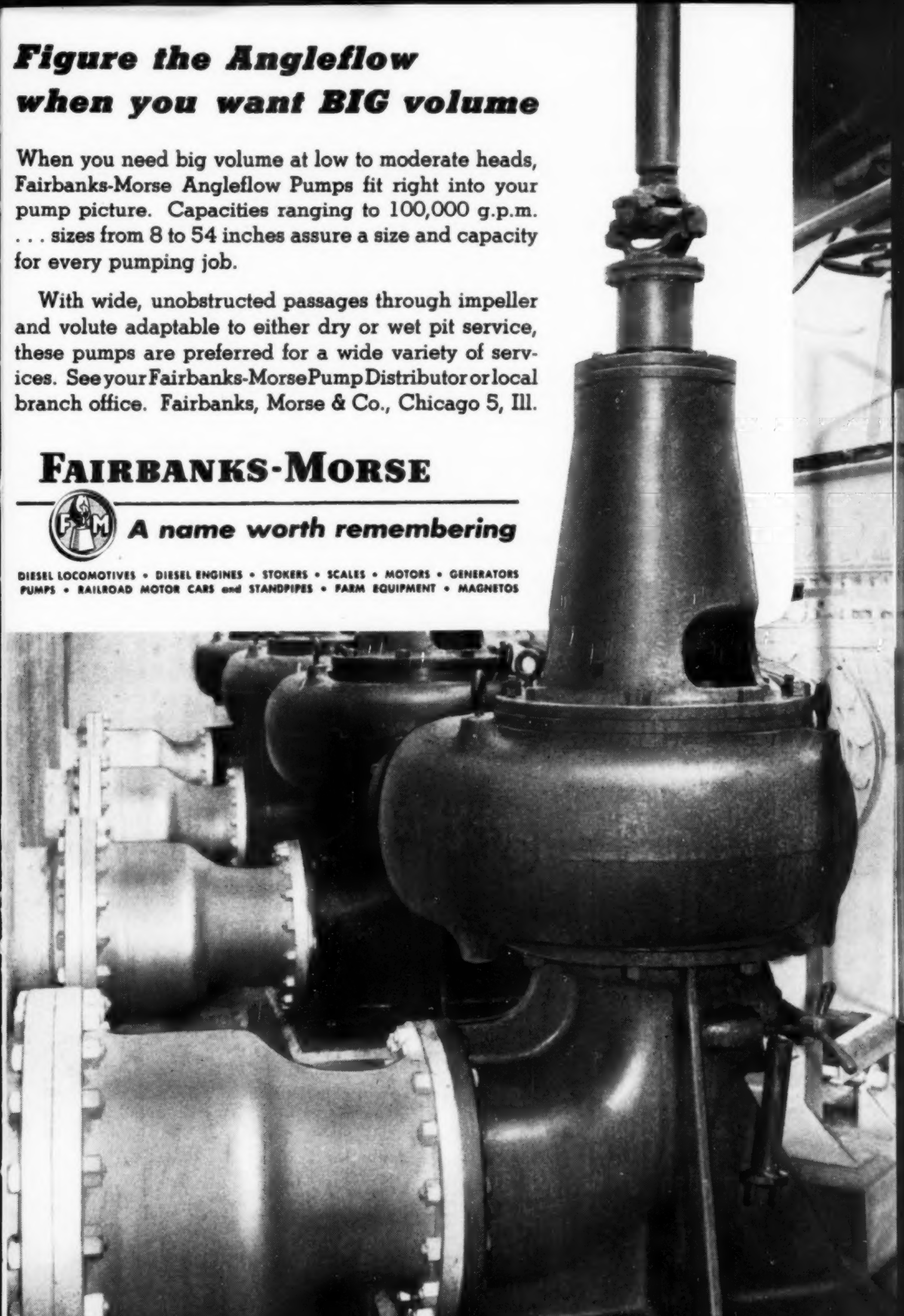
Shealy, Gerald O., Filter Plant Operator, Com. of Public Works, 946 Cornelia St., Newberry, S.C. (Apr. '49)

Shipley, Charles G., Plant Supt., Comr. of Public Works, R.F.D. 2, Box 122, Naval Base, S.C. (Apr. '49)

Simpson, Alfred G., Supt. of Utilities, Box 732, Blaine, Wash. (Apr. '49)

Sioux Lookout, Town of, Public Utilities Dept., Albert Wren, Mgr., Water Works, Sioux Lookout, Ont. (Corp. M. Apr. '49)

(Continued on page 34)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(Continued from page 32)

Snyder, C. L., Partner, Snyder, Wolford & McLellan, Hillsboro, Ind. (Apr. '49)

Spennato, S. J., Clerk-Treas., Box 95, Hearst, Ont. (Apr. '49)

Stuppy, Mark Leonard, Sales Engr., Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia 42, Pa. (Apr. '49) *P*

Tait, Robert E., San. Engr., Dept. of National Health & Welfare, Public Health Eng. Div., 211 Industrial Bldg., Halifax, N.S. (Apr. '49)

Thomas, Harold E., Dist. Geologist, U.S. Geological Survey, 303 Federal Bldg., Salt Lake City 1, Utah (Jan. '49)

Thomas, Howard S., Cons. Engr., 315 Alexander St., Rochester 4, N.Y. (Apr. '49)

Tidwell, D. V., Jr., Salesman, Eng. & Equipment Co., 1468 N.W. 13th Terrace, Miami, Fla. (Apr. '49)

Tilson, Fred O., Dist. Sales Mgr., Mathieson Chemical Corp., Lock Box F, Marshall, N.C. (Apr. '49)

Vance, James B., *see* Washington County San. Dist. No. 1

Wagner, E. C., *see* Nebraska Inspection Bureau

Warren, Pierre, Cons. Engr., 105 Cote de la Montagne, Quebec City, Que. (Apr. '49)

Washington County San. Dist. No. 1, James B. Vance, Mgr., Abingdon, Va. (Corp. M. Apr. '49)

Waterloo Water & Light Com., Edmund R. Wagner, Supt. of Utilities, Waterloo, Wis. (Corp. M. Apr. '49) *MPR*

West, William A., Sales Mgr., R. D. Wood Co., 591 Lindberg Blvd., Berea, Ohio (Apr. '49)

Whitfield, Cyrus Edward, Chemist, Tennessee Valley Authority, 407 N. Gay St., Knoxville, Tenn. (Apr. '49)

Widmer, Wilbur J., Instructor of Civ. Eng., Univ. of Connecticut, Dept. of Civ. Eng., Box U-37, Storrs, Conn. (Apr. '49) *P*

Wilson, W. F., Mgr., Eng. Sales Dept., Crane Ltd., 306 Front St., W., Toronto, Ont. (Apr. '49)

Wolfe, W. W., Asst. Mgr., Chicago Office, American Cast Iron Pipe Co., 1311 First National Bank Bldg., Chicago 3, Ill. (Apr. '49)

Woods, William A., Mgr., Public Utilities Com., 207 Division St., Box 177, Cobourg, Ont. (Apr. '49)

Wren, Albert, *see* Sioux Lookout, Town of

Yellow Springs Board of Trustees of Public Affairs, Norman E. Meranda, Supt. of Utilities, Box 226, Yellow Springs, Ohio (Corp. M. Apr. '49)

Zinter, L. F., Supt., Water Works, Parkers Prairie, Minn. (Apr. '49)

REINSTATEMENTS

Barnes, George William, Supt., Water Dist., Hillside Ave., S. Huntington, N.Y. (Apr. 147)

Brown, Abraham, Acting Div. Engr., Div. of Designs, Dept. of Water Supply, Gas & Elec., 2400 Municipal Bldg., New York 7, N.Y. (Apr. '46)

Camel, Blaise G., Chairman, Finance Com., East Jefferson Water Works No. 1, 503 Lake Ave., Metairie, La. (Oct. '42)

Fields, Bert, Mgr., Kentucky Water Co., Box 588, Jenkins, Ky. (July '45)

Fry, James H., Chief Chemist, Water Works Dept., Filtration Plant, R.R. 1, Lebanon Rd., Nashville 10, Tenn. (July '34) *MP*

Jepson, A. E., Comr., Town of Fort Erie, 200 Jarvis St., Fort Erie, Ont. (Jan. '47)

Wagner, Nelson J., Mfrs. Repr., 1946 Main St., E., Rochester 9, N.Y. (July '46)

Weagraff, Charles R., Water Supt., 41 Main St., Salamanca, N.Y. (July '35) *MP*

White, Horace L., Asst. Supt., Indian Hill Village, Williamsburg, Ohio (Oct. '40)

LOSSES

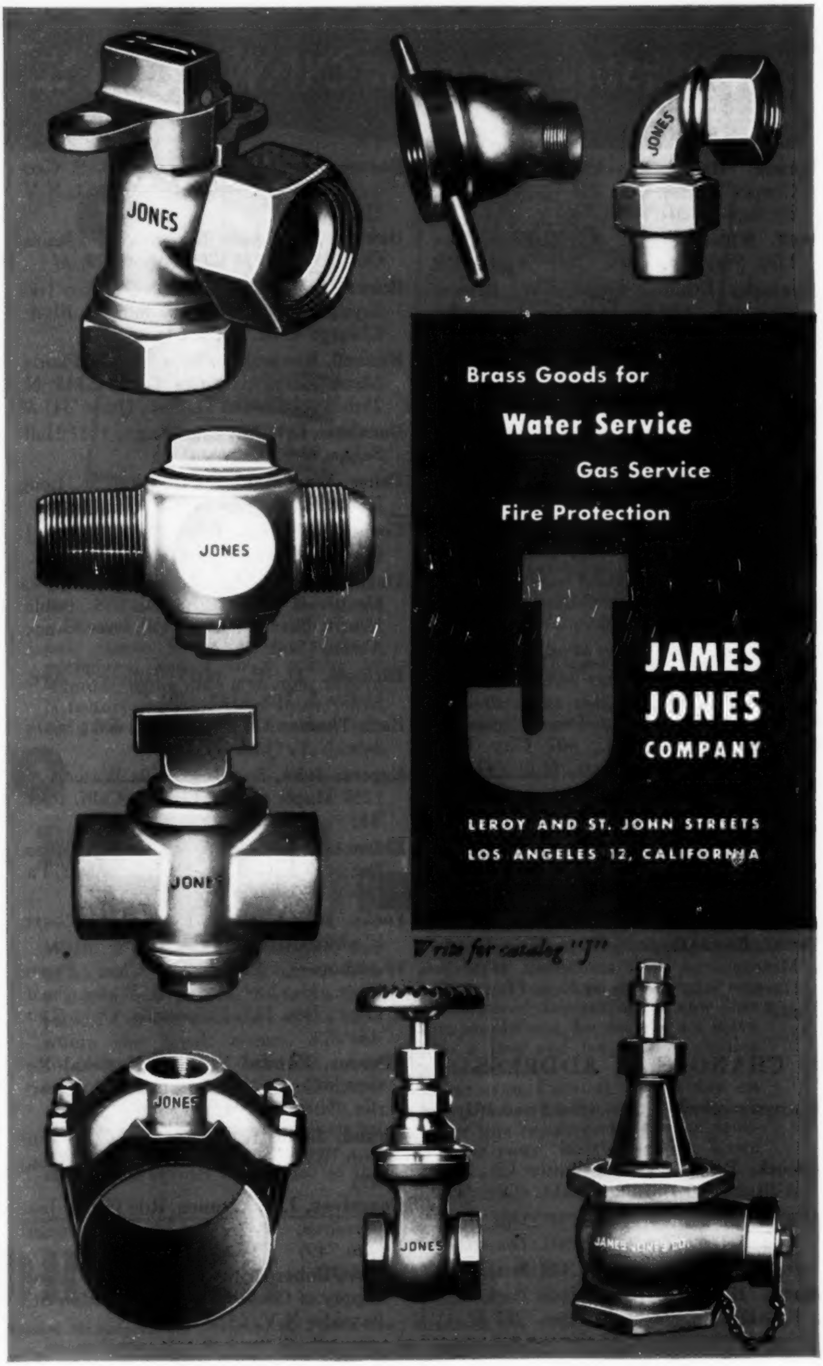
Deaths

Cooper, George W., Gen. Mgr., Monterey Bay Water Co., Box 801, Santa Cruz, Calif. (Oct. '43) *M*

Henderson, Charles T., Chief San. Inspector, Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '44)

Howard, Roscoe R., Supt., Munic. Utilities, Slater, Mo. (Oct. '46)

(Continued on page 36)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Quirk, M. Edward, Foreman, Water Dept., 38 Sutton St., Peabody, Mass. (Apr. '37)

Resignations

Carson, Harry R., Vice-Pres., Harry Cooper Supply Co., 223 E. Water St., Springfield, Mo. (Oct. '46)

Duff, William, Supt. of Filtration, Box 178, Malartic, Que. (July '42) *MPR*

Kentucky Utilities Co., E. W. Brown, Vice-Pres., 159 W. Main St., Lexington 3, Ky. (Corp. M. Feb. '05) *MP*

Lavelle, John, Asst. Supt., Water Distr. Div., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (Oct. '32) *M*

Parrish, Dorothy M. (Mrs.), Geological Survey, Oklahoma A & M College, 306 Chemistry Bldg., Stillwater, Okla. (Oct. '44) *R*

Roberts, Charles E., Civ. Engr., Water Board, Eugene, Ore. (Oct. '47)

Schwarz, George M., 985 N. Capitol St., Salem, Ore. (Jan. '47)

Spencer, Harold, Water Works Foreman, Elec. & Water Dept., Marshfield, Wis. (July '44)

Sullivan, Daniel M., Deputy Comr., Public Works Dept., 607 City Hall Annex, Boston 8, Mass. (July '41) *M*

Wittichen, Carl, Pres., Wittichen Chemical Co., 1609 S. 2nd Ave., Birmingham, Ala. (Jan. '48) *P*

Wood, J. G., Mgr., Texarkana Water Corp., 611 Pecan, Texarkana, Ark. (July '43) *M*

Young, Kenneth, Asst. Engr., Eng. Dept., Metropolitan Utilities Dist., 18th & Harney Sts., Omaha 2, Neb. (Jan. '41) *MP*

CHANGES IN ADDRESS

Changes received between April 5 and May 5, 1949

Adcock, R. W., Adcock Water Co., 467 Williams Rd., Salinas, Calif. (Oct. '42)

Allison, S. L., Supt., Sewer Dept., 606 Hoffman St., Corpus Christi, Tex. (July '47)

Barton, Harry, 127 New Hyde Park Rd., Franklin Square, N.Y. (Dec. '28) *M*

Black, Hayse H., Chief, Indus. Waste Section, U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (Oct. '33) *PR*

Bogart, Dean B., Hydr. Engr., U.S. Geological Survey, Box 948, Albany 1, N.Y. (July '45) *R*

Bowman, Abraham M., Box 8, Elmira, Ont. (Oct. '19) *Fuller Award '39. M*

Brown, James R., Dist. Mgr., Trojan Tool Equipment Co., 141 W. Jackson Blvd., Chicago 4, Ill. (July '34) *M*

Bunnell, Kenneth J., Supt., Water Plants, Metropolitan Utilities Dist., 5335 N. 25th Ave., Omaha 11, Neb. (June '34) *M*

Burnham, Lyle M., Sales Engr., 1157 Hall, Salem, Ore. (Oct. '40)

Calise, Vincent J., 603 W. Olive St., Long Beach, N.Y. (Jan. '48) *P*

Cooper, Robert A., Box 777, Passaic, N.J. (Apr. '46) *P*

Day, Elroy K., Sr. San. Engr., Alaska Health & San. Activities, U.S. Public Health Service, Box 960, Anchorage, Alaska (Jan. '48) *P*

Dickson, D. B., 6005 Hillcrest Ave., Dallas 5, Tex. (Jan. '39) *P*

Earl, Thomas C., 65 Tunstall Rd., Scarsdale, N.Y. (Jan. '47) *MP*

Eggers, John, San Jose Hills Water Co., 1250 Maple Grove, Puente, Calif. (Oct. '48)

Eidsness, Fred A., Dist. Engr., Infilco, Inc., 117 S. 17th St., Philadelphia 3, Pa. (May '41) *Fuller Award '44. P*

Fooks, Jack Herbert, 136 Fellows Court, Elmhurst, Ill. (Jan. '47) *R*

Frankhouser, Elmer V., Chief Power Engr., Head of Power & Water Purif. Dept., Box 545, Painesville, Ohio (Oct. '44) *P*

Gibbons, Edward Vincent, National Research Council, 96 Research Rd., Quarries, Ont. (Jan. '42)

Girand, James, Cons. Engr., 1622 Palmcroft Way, S.E., Phoenix, Ariz. (Jan. '49)

Gonzalves, J. J. Autunes, Ruo Carlos Jose Barreiros, 14-2nd, Lisbon, Portugal (Jan. '49)

Grieve, Robert M., Supt., Citizens Water Supply of Great Neck, 2918 Jordan St., Bayside, N.Y. (Apr. '47) *P*

(*Continued on page 38*)

(Continued from page 36)

Groff, Gilbert, Groff & Clark, Cons. Engrs., 3175 S. Commercial St., Salem, Ore. (July '46) *P*

Harris, Stanford E., Supt., Dept. of Water & Sewerage, Winston Salem, N.C. (Jan. '46) *M*

Heiney, J. W., Asst. Div. Mgr., Water Works Service Co., Inc., 1431 Ripley St., Davenport, Iowa (Oct. '46)

Heller, Jesse E., 64 N. Chester St., Pasadena, Calif. (Jr. M. July '48)

Hoskin, Douglas G., 705—6th St., Saskatoon, Sask. (Jr. M. Jan. '48) *MP*

Ingram, William T., Assoc. Prof., Public Health Eng., New York Univ., Box 106, University Heights 53, N.Y. (July '35) *P*

Jenkins, Joe E., 3245 Locke Lane, Houston, Tex. (July '42)

Jodaitis, Ladislaus T., U.S. Public Health Service, 69 W. Washington, Chicago, Ill. (July '43) *P*

Knodel, Adolph Robert, Assoc. Professional Scientist, State Water Survey Div., Box 717, Peoria 1, Ill. (July '45) *R*

Lanigan, Roy A., Acting Supt., Water Dept., Box 191, Burlingame, Calif. (Apr. '47)

Leary, Charles J., 318 W. 3rd, Madison, Ind. (Oct. '45)

Lee, W. Howard, Lee Eng. Service, Box 85, Denville, N.J. (Oct. '40)

Licht, Carl M., 1725 Wilson Ave., Chicago 40, Ill. (Jan. '48)

Liquid Conditioning Corp., 3130 N. 17th St., Philadelphia, Pa. (Assoc. M. Jan. '48)

Macomber, Ronald Gibbs, Acting State San. Engr., Delaware State Board of Health, 4329—4th St., S.E., Washington, D.C. (Jan. '48)

Mayhew, N. R., Supt. of Water Operations, 2800 Airport Way, Seattle 4, Wash. (Jan. '46) *MPR*

Murray, Walter, Engr., H. J. McFarland Constr. Co., Ltd., Picton, Ont. (Jan. '48) *MPR*

Nova Scotia Board of Insurance Underwriters, W. Shakespeare, Mgr., 50 Sackville St., Halifax, N.S. (Corp. M. Oct. '40)

Nutting, N. C., Gen. Supt. of Operations, California Water Service Co., 374 W. Santa Clara St., San Jose, Calif. (Sept. '33)

Parker, Garald Gordon, U.S. Geological Survey, Water Resources Div., Washington 25, D.C. (Jan. '46) *R*

Peterson, C. J., Town Mgr., Town Hall, Wray, Colo. (July '46) *PR*

Robertson, D. A., Jr., Asst. Engr., State Health Dept., 713 State Office Bldg., Richmond, Va. (Oct. '48)

Robinson, J. Albert M., Box 1185, Chicago 90, Ill. (Oct. '31) *PR*

Sanders, John F., 915—3rd St., Boonville, Mo. (Oct. '43) *M*

Sieveka, Ernest H., Engr., Water Supply Branch, Research & Development Lab., Fort Belvoir, Va. (Apr. '42)

Spier, William J., Water Supt., Pocatello, Idaho (Apr. '46)

Stephan, Dean E., Mgr., Los Angeles Office, Chicago Bridge & Iron Co., 612 S. Flower, Los Angeles 14, Calif. (Apr. '45)

Steward, W. R., Supt., Water & Sewer System, Searcy, Ark. (Jan. '42)

Taylor, Robert L., Hydr. Engr., U.S. Geological Survey, Sebring, Fla. (Jan. '45) *P*

Thomas, George E., Clerk, Board of Public Affairs, 1 River St., Willoughby, Ohio (July '47)

Thompson, Joseph, Rohm & Haas Co., Washington Sq., Philadelphia 5, Pa. (Jan. '47)

Tomlinson, Walter John, c/o E. F. Drew & Co., Ltd., 726 University Tower Bldg., Montreal 2, Que. (July '38) *P*

Walton, Graham, Water & San. Investigations, U.S. Public Health Service, 1014 Broadway, Cincinnati 2, Ohio (Jan. '41) *P*

Ward, Sylvester E., Mgr., Somerville Water Co., 9 Division St., Somerville, N. J. (Jan. '43) *MP*

Waring, William H., Staff Mgr., Houston Dist., Transite Pipe Sec., Johns-Manville Sales Corp., Box 8217, Houston 4, Tex. (Jan. '42)

Whitefield, Leonard F., Eng. & Development Div., Imperial Oil, Ltd., Sarnia, Ont. (Apr. '46) *P*

Wood, Alan A., Alan A. Wood, Inc., 1649 N. Broad St., Philadelphia 22, Pa. (Jan. '44) *P*

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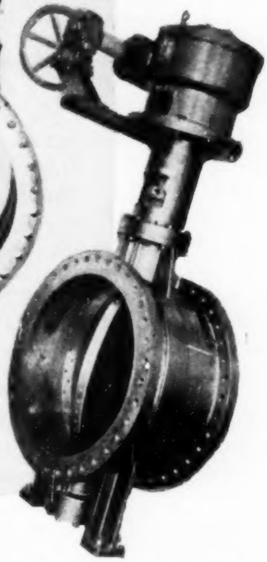

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene* (*Great Britain*); *C. A.—Chemical Abstracts; I. M.—Institute of Metals* (*Great Britain*); *P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research* (*Great Britain*).

ADMINISTRATION

Is Joint Administration of Water and Sewage Works Advisable? Wtr. & Sew. (Can.) **85**:10:64 (Oct. '47); **85**: 11:27 (Nov. '47). Symposium at Convention of Can. Inst. on Sewage and Sanitation. L. G. McNeice. Experience in Orilia, Ont., with 35-yr. joint operation of hydroelec. and water systems favorable. Advantages include: greater continuity of personnel and policy, closer attention to details, experienced businessmen more ready to serve on commissions than in municipal politics, greater freedom from politics, efficient operation without temptation to divert funds for other purposes, and commission more ready to engage and act upon competent engineering advice. W. M. Veitch. Separate admin. of water and sewerage systems more efficient and economical in London, Ont. Sewage disposal under jurisdiction of city engineer, along with other nonprofit services; hydroelec. and water systems and parks under public utilities commission, all revenue-producing. Latter three dovetail; power required for pump operation, and water system lands are public parks. Author, however, favors joint billing, with charge for sewage disposal as separate item but levied with water bill. Opening of streets for repairs is one disadvantage of separate admin. Joint admin. may be necessary for municipalities of about 10,000 pop. William Davidson. Joint admin. superior for municipalities of 10,000 pop. or under. Separate admin. would involve duplication of personnel, equipment and service buildings. In Whitby, Ont., pop. 4500, joint control satisfactory. F. N. McCallum. Continuity of service in city councils often as long as on commissions. Policy of commission, as well as that of council, may be consistently bad. Political interference can be avoided by strict definition of authority and responsibilities of department head. No reason why utility surplus, after providing for maintenance, obsolescence, etc., should not be used for maintenance of other public property. Large industries have as great variety of activities and problems as municipalities but administered by 1 board of directors. Multiplicity of boards and commissions undesirable—integration needed, not separation. City councils should recover powers lost, not delegate more to commissions.—*R. E. Thompson.*

Planning Municipal Public Utilities. R. Del French. Eng. Cont. Rec. (Can.) **60**:12:61 (Dec. '47). Intelligent planning will avoid inconvenience and expense but cannot provide for all contingencies. Back-of-lot location of utility lines in "utility strip" owned by municipality or by easement or servitude along rear of lots avoids pavement breakage for repairs, traffic interruption, etc., but necessitates longer service lines and hydrant connections. Adequate location records essential.—*R. E. Thompson.*

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Restricted Water Supplies. C. W. CASSÉ. Wtr. & Wtr. Eng. (Gt. Br.) **51**:413 (Sept. '48). When designing water works, basic problem to settle is avg. and max. daily demand. Answer not possible in many parts of world. Detailed anal. of available consumption statistics necessary. Why, for instance, is avg. consumption per head for many small places in Scotland higher than for Metropolitan Water Board area? Accurate statistical consumption details under following headings required: [1] domestic supplies—house service, washing and drinking; garden watering; garage and miscellaneous use; [2] nondomestic supplies—bulk supplies to factories; metered supplies to small traders; offices and institutions; road watering; drain flushing; fire; swimming pools and miscellaneous. Some factors which influence water consumption are: degree of control of invisible and visible waste by water authority, control of distr. pressure, method of supplying customers (i.e., directly from mains or through house cisterns), daily hours of supply, cost of water, habits of populace, and nature of water service facilities—whether standpost supply only or compulsory connection to every dwelling, avg. no. of taps per dwelling, no. of baths and showers and no. of garden taps or taps outside dwellings. Perhaps in near future, if not at present, halt will have to be called to unrestricted public use of water supplies. To suit conditions, cost of water would receive prior attention. Restriction would almost inevitably mean general metering. In tropical, nonwesternized country with continuous, full-pressure supply and connection to every dwelling, nonrestricted water supply demand would be almost infinite. Surprising that consumption so low in western countries. In any water works, continuous pressure should be *sine qua non.* Control of supply has been solved at Mombasa

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and other places in East Africa. All house connections metered. Native and Indian public supplied from standposts operated by "turncocks" at specified times of day. General metering demands strict administration, not always experienced. It does not appear logical soln. for some countries of East to adopt definite restrictive measures. At Cawnpore, in '38, area of supply divided into zones supplied by means of low-pressure mains delivering definite amt. of water into storage reservoirs at ground level. Automatically controlled pumps drew water from reservoirs and pumped it into zone supply mains at pressures which varied according to time of day and level of water in storage reservoirs. System worked all right up to point but did not prevent those near boosting stations from using excessive water. Consumption figure assumed by municipality soon found to be totally inadequate. Conclusion is that not only in eastern countries, but also in western, principal of restricted supply and more general use of meters on domestic connections will have to be adopted.—*H. E. Babbitt.*

Waste Water Inspectors of the Future. Arthur Gilbert. Wtr. & Wtr. Eng. (Gt. Br.), **51**:480 (Oct. '48). Water works industry in danger of becoming home for dullards, misfits and riffraff seeking safe jobs. Lack of competition has been quoted as probable cause but equal factor is sometimes lack of interest on part of those responsible for selecting candidates. Day is gone when duties of waste inspectors began and ended with listening for possible sound of leakage. Inspectors now called on to solve

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problems of varying complexity and deal with consumers of higher general std. of intelligence. Inspector of today, and more so of tomorrow, must be intelligent, with real interest in job. Inspector of future will be required to know something of hydraulics, mathematics, chemistry and theory and practice of waste detection. Various water systems have instituted training schemes. Their inspectors are expected to pass examns. and are paid according to results thereof. Eventually no candidate for these posts will be able to get worth-while job without having necessary qualifications.—*H. E. Babbitt.*

A Study of Repetition of Accidents. D. ARCHIBALD & J. W. WHITFIELD. Brit. J. Ind. Med. (Gt. Br.) **4**:2:107 (Apr. '47). Statistical anal. of personal accident records has already shown that, among group of workers exposed to same risk of accident, "accident-prone" minority will suffer more accidents than reasonably expected on purely chance basis. Present study deals with distr. of accident injuries classified by operation engaged in at that time, part of body affected and nature of injury incurred. Sickness records for individuals differently occupied in royal ordnance factory (eng.) analyzed to compare frequency expected on chance basis of individual sustaining 2 or more accidents either in same operation, to same site, or of same nature, with frequency actually observed. From results of anal. authors deduce that individuals who have more than 1 accident are more likely to have accidents of same type—e.g., same part of body being involved—than might be reasonably expected from risks of their occupation. This may be for one or more possible reasons: they may tend to have accidents at same operation of their work; they may tend primarily to injure same part of body; or they may tend to report one

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type of injury, e.g., burns, rather more frequently than others. Expected frequencies based on each of these 3 hypotheses compared with actual observations, and x^2 test shows that none of 3 gives satisfactory fit. It may be, however, that experience with longer exposures and larger numbers in more homogeneous groups would demonstrate closer agreement, particularly with hypothesis that certain machine operations unusually hazardous for particular individuals. If this were so, then operations particularly likely to cause injury to any one individual could be recognized, and his training modified to elim. personal manipulative habits which made him thus susceptible.—*B.H.*

Proceedings of the Tenth Annual Short Course for Water and Sewerage Plant Superintendents and Operators, 1947. La. State Univ. Eng. Expt. Sta. Bul. Series No. 11 (1948). **The Occurrence of Ground Water in Louisiana.** P. H. Jones (p. 7). Of 219 municipal water supplies, 190 from wells, their total avg. consumption being over 50 mgd. Geologic principles underlying occurrence of ground water and general geology of Louisiana explained. State may be divided into 6 zones when describing geologic origin and characteristics of ground water. These are mapped, and geologic cross sections shown of well fields near Alexandria and Natchitoches. **Automatic Electric Control for Small- and Medium-Size Water Works Plants.** F. E. Dunham (p. 15.) Automatic control of small plants permits operation with only one man in attendance, who also reads meters, collects bills and maintains equipment; frequent checks of

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equipment made several times daily without interfering with other activities. Details described for controlling well pumps, service pumps, chemical feeders and small filter plants. **Control of Upflow Type Sedimentation Basins.** Daniel L. Winters (p. 29). Difficulties encountered at New Iberia include: controlling height and density of sludge, development of tastes unless basins cleaned frequently, fluctuations in chlorine residual and aversion to overload. Raw water containing 3 ppm. of iron is lime-softened in 2.5-mgd. precipitator without further coagulant. pH drop across coated sand filters varies from zero to 0.1 at or near pH 9.4. Avg. hardness of final effluent is 10 ppm. below that with old sedimentation tank. Turbidity of precipitator effluent was reduced by flushing back blowoff piping only before sludge blowoff, to avoid disturbance caused by separating these processes. Chlorine dosage, following aeration, has increased over that for old sedimentation tank due to demand in sludge and turbidity of effluent. Best operation is found when sludge consistency between 1.0 and 1.6% and height of sludge layer kept 72″ below water surface. **Use of Flames in Disinfecting Reservoirs.** Robert L. Martin (p. 38). Nematodes, thought to enter screened reservoir through numerous cracks in concrete roof once covered with earth, resisted heavy treatment with copper sulfate and chlorine solutions. Position of overflow line prevented flooding of ceiling. Flames from natural gas torches passed slowly enough over ceiling and walls to permit heating of concrete. Connections for torches provided every 25′ along reservoir. Flaming reported successful also in eliminating chironomous larvae at Church Point and isopod at White Castle reservoirs. **Chlorine, Chloramines and Ozone: A Comparison.** J. A. K. van Hasselt (p. 43). Popularity of chlorine over ozone due

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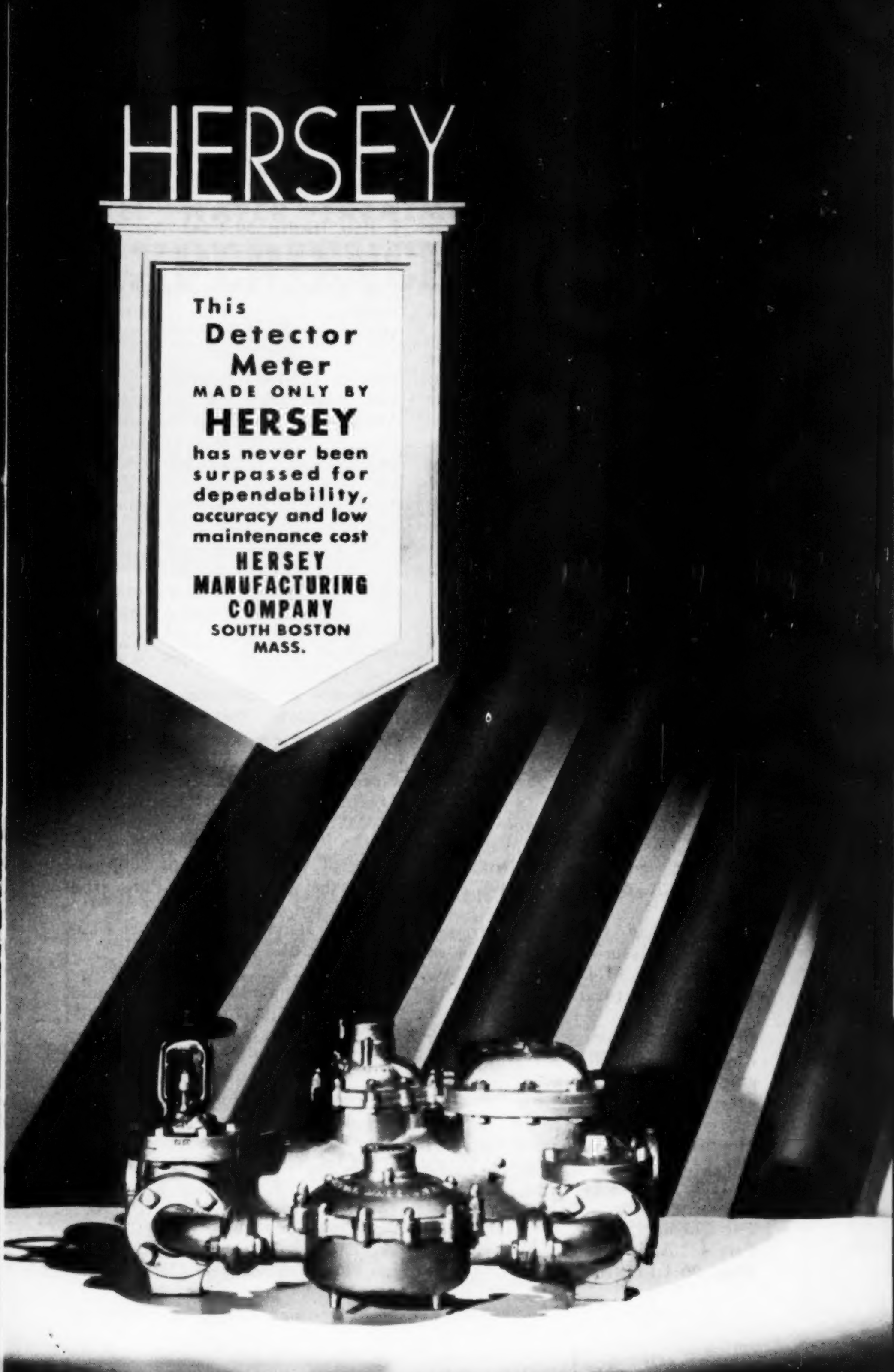
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to relative cheapness and availability in readily usable form for feeding from equipment that is inexpensive in comparison. Ozone residual is not so stable, hence cannot be used for action out in distribution system. Effect of ozone remains same from 1 to 4 ppm. It can be breathed without discomfort. Unlike chlorine, variation in pH does not affect killing time. Like free chlorine, ozone inactivates polio virus. Like chlorine dioxide, ozone removes phenolic tastes. Alone, or in combination with chlorine, ozone is valuable tool for taste and odor control. Ozone residuals are read with ortho-tolidine, starch iodide, or Eastman's tetra base paper. Differential test for ozone when present with chlorine is liberation of both iodine and rosolic acid from special double-impregnated test paper. At present 3 companies in U.S. make ozonators, described in some detail.—*A. A. Hirsch.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

An Inverted Siphon for the Assabet River Crossing of the Wachusett Aqueduct. STANLEY M. DORE. J. N.E.W.W.A., **63**:1:1 (Mar. '49).

Production of 84-Inch Prestressed Concrete Pressure Pipe for City of Montreal. R. M. DOULL. J.N.E.W. W. A., **63**:1:29 (Mar. '49).

Ten New Swimming Pools in Los Angeles Expanded Recreation Program. C. P. L. NICHOLLS. Western City, **25**:4:26 (Apr. '49).

Fluoridation as Practiced at Madison, Wis. L. A. SMITH. Wtr. & Sew. Wks., **96**:4:125 (Apr. '49).

The Chemistry of Water Treatment, Part 4. A. P. BLACK. Wtr. & Sew. Wks., **96**:4:133 (Apr. '49).

Some Public Health Problems in Nuclear Fission Operations. ARTHUR E. GORMAN & ABEL WOLMAN. Am. J. Pub. Health, **39**:4:443 (Apr. '49).

Water Pollution—A Policy and Program for Control. Maryland Water Pollution Control Com., Baltimore, Md. (Jan. '49).

Factors Influencing Self-purification and Their Relation to Pollution Abatement. II. Sludge Deposits and Drought Probabilities. C. J. VELZ. Sew. Wks. J., **21**:2:309 (Mar. '49).

Modern Concepts Applied to Concrete Aggregate. R. F. BLANKS. Proc. A.S.C.E., **75**:4:441 (Apr. '49).

Control of the Hydraulic Jump by Sills. JOHN W. FORSTER & RAYMOND A. SKRINDE. Proc. A.S.C.E., **75**:4:469 (Apr. '49).

Essentials in Corrosion Prevention. E. B. RODIE. Pub. Wks., **80**:4:33 (Apr. '49).

Corrosion Control by Threshold Treatment. JOHN H. WHITE. J.N. E.W.W.A., **63**:1:96 (Mar. '49).

Effect of Various Aqueous Solutions Upon the Reactions at Pure Iron Anodes and Cathodes—Part I. W. W. KITTELBERGER & A. C. ELM. Corr., **5**:4:101 (Apr. '49).

Seismic Reconnaissance for Ground Water Development. DANIEL LINEHAN & SCOTT KEITH. J.N.E.W.W.A., **63**:1:76 (Mar. '49).

Watershed Inspections in Connecticut Including Problems of Housing Developments. FREDERICK O. A. ALMQUIST. J.N.E.W.W.A., **63**:1:57 (Mar. '49).

Insurance Problems of Water Works Companies. CHARLES C. GOODRICH. J.N.E.W.W.A., **63**:1:45 (Mar. '49).

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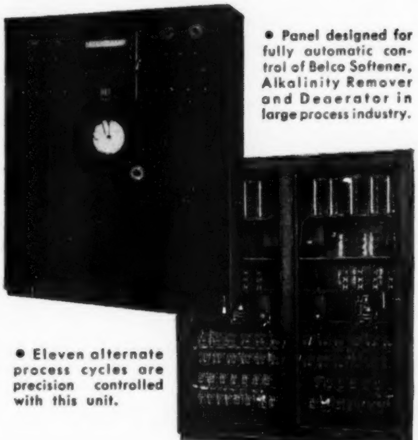

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PROCESSES FOR REMOVAL OF WATER IMPURITIES

(Continued from page 20)

New York State's pollution control bill became law on April 20 when the measure, the outcome of a three-year study by a special legislative committee, obtained Governor Dewey's signature. The law establishes a board which will classify the waters of the state according to quality and purity; issue orders prohibiting discharge of wastes into watercourses; encourage the drawing of plans to prevent pollution; and prepare a comprehensive pollution control plan. The board is composed of the state commissioners of health, conservation, agriculture and markets, commerce and the superintendent of public works.

H. Lloyd Nelson, Eastern Sales Manager of the U.S. Pipe & Foundry Co., has been granted a leave of absence to serve as President and General Operating Manager of the Pontusco Corp. and the Pontusco Corp. of Cuba. These organizations, formed in 1946 to manufacture concrete pipe and associated products in North, Central and portions of South America, are jointly owned by U.S. Pipe & Foundry Co. and the Compagnie de Pont-a-Mousson of Nancy, France. Nelson, a graduate civil engineer, has been with U.S. Pipe and Foundry Co. in various capacities for 25 years.

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"Uniform System of Accounts for Sewer Utilities" is a tentative Manual of Practice just published by the Federation of Sewage Works Assns., and designed to be intelligible even to those unfamiliar with accounting. Introductory chapters explain fundamental concepts and their applications to sewer utilities, while the remainder of the book is devoted to systems of accounts and explanatory appendixes, including the very useful 21-page glossary of accounting terms. The 117-page manual is an adaptation of the A.W.W.A.–M.F.O.A. *Manual of Water Works Accounting*, and therefore also conforms to the general system developed by the National Assn. of Railroad and Utilities Commissioners. Copies, priced at $5, are available from the Federation at 325 Illinois Bldg., Champaign, Ill.

The growing interest in fluoridation is only one among many manifestations of the current campaign to conserve our molars. What with chemical seals, ammoniated toothpowders, brushless toothbrushes and such substances as the acid-retardant recently isolated from human saliva, we appear well on our way to ending decay. And that it is high time, too, has been all too dramatically proved by a gadget called the "gnathodynamometer," recently developed by members of the Tufts College faculty and

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displayed at last month's Boston convention of the Massachusetts Dental Society.

Registering bite pressure visually through a cathode ray oscilloscope and, independently, on a needle gage, this new chew gewgaw has already demonstrated that the normal mouthful of natural gnashers can exert a pressure up to 250 psi., whereas the average jawful of falsies can do no better than a puny 30 psi. And, although this latter bite has been proved adequate to manage such gnaw-numbers as apples, requiring up to 20 psi., and steak or peanuts, at 12 psi., the conscientious gnathodynamometrists have observed that most synteethics steer clear of the roughage they need. Thus, they're busy now devising de luxe dentures equipped with steel cutting edges.

The trouble is, of course, that just as soon as these new hollow-ground grinders become available, people are going to be dissatisfied with nature's own dull tools. And then instead of conservation, we'll be campaigning for "Replacement—Not Substitution." How much help such tales as that of the Indianapolis woman who recently reported to the city board of health that her dentist had removed her false teeth and refused to return them because she was behind in her payments will be depends entirely upon the future economic picture. But, expecting it to be bright, we may well now forget fluoridation and begin treating our water to make it rust- and corrosion-proof.

Modern Sanitation is the title of a new monthly magazine of industrial and institutional sanitation. On the editorial board are such familiar names as William T. Ingram, W. L. Mallman and Sol Pincus. The avowed purpose is to stimulate interest and further the scope of sanitation practice in institutions and factories, where progress has been confined to a minority of alert organizations. Subscriptions, at $2.00 the year, from the publication offices, located at 855 Avenue of the Americas, New York 1.

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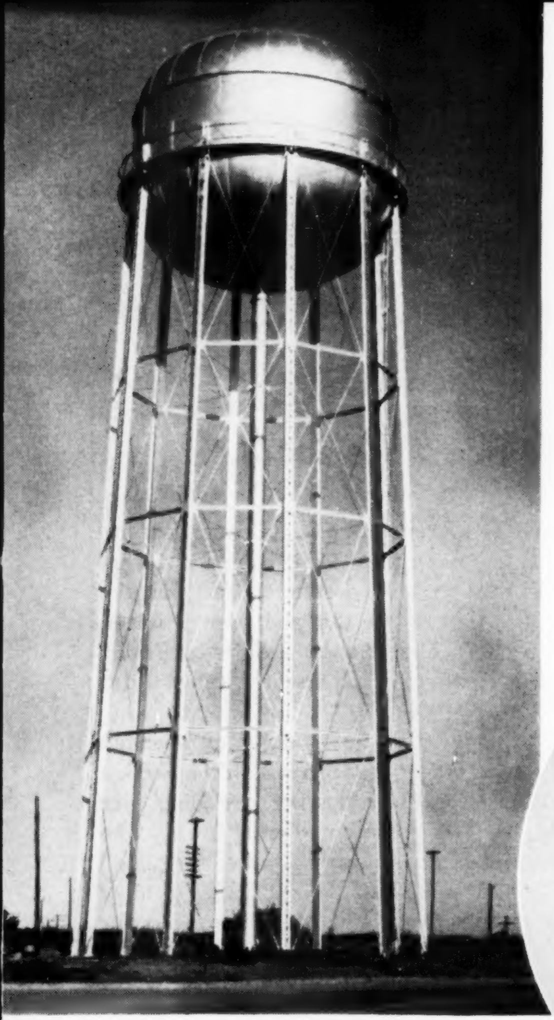
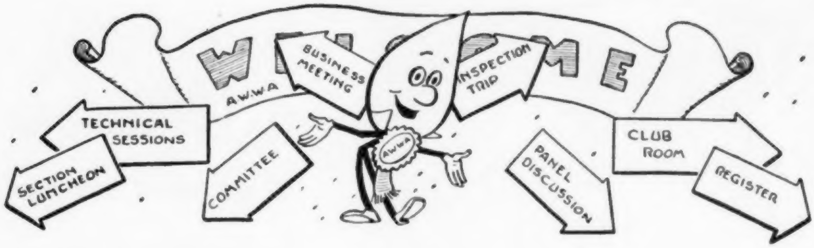
Water bids fair to replace the elephant. Now that a series of experiments by Dr. N. E. Dorsey of the National Bureau of Standards has definitely proved not only that water can learn and understand, but that it has a "very long memory," there is obviously no longer reason to perpetuate the scientifically fallacious maxim which has made the elephant our symbol of rememberability. Soon, too, we will no longer accuse each other of having "water on the brain," but render a compliment in so saying.

Announcement of this new concept was made at a recent meeting of the Southern Society of Philosophy and Psychology by Dr. H. M. Johnson, Tulane University psychologist, who described Dorsey's procedure of experimenting with samples of pure water hermetically sealed in clean glass tubes. By alternately freezing and thawing these samples, Dorsey found that they soon adjusted themselves to freeze at lower temperatures, differing among individual samples—the aptest freezing at a temperature close to zero Fahrenheit and the dullest some 20 degrees above that. Continuing his experiments over a period of 20 years, Dorsey was able also to establish the fact that once the samples learned these lower freezing temperatures they did not forget them regardless of the lapse of time between freezings. Acknowledging that scientists have long known that non-living systems can learn and remember, Johnson pointed out that that ability had always been considered so slight as to be insignificant. The Dorsey discovery of course changed this, so that Dr. Johnson was willing to state that water understood its task and, even as you and I, behaved according to its past experience.

To water works men, who have always been careful, if not solicitous, in their treatment of water, this revelation need of course cause no great alarm. They may well, however, take into their future consideration the personality of each portion, suggested by the apparent rugged individualism of Dorsey's samples. And if utility men themselves do not soon adopt this new appreciation of water's intellect—perhaps even emotions—certainly our leading manufacturers of treatment chemicals will respond without delay. Any day now, we expect to run an advertisement for "The Chlorine Your Water Demands!"; perhaps even, "Croton Water has switched to Calgon, because . . ." At any rate, you will do well not to mistreat your water, since you can't make up to it by buying peanuts.

"Standard Welding Terms and Their Definitions" has just been published by the American Welding Society, 33 W. 39th St., New York 18, to formulate a suitable, standard terminology. Among the useful distinctions drawn are those between such related concepts as "fusion," "penetration" and "bond"; "bead weld" and "weld bead"; "backing weld" and "back weld." A "Master Chart of Welding Processes" and individual "Process Charts" are being issued concurrently. The book is priced at $1.00 and the charts at 35¢ per set of five ($1.25 in combination).





Section Meeting Reports

Arizona Section—The Spring Conference of the Arizona Section, held in Prescott on April 1–3, was hailed by the 133 registered members and guests as one of the most successful yet held, despite the fact that the weatherman swung heartily into the spirit of the day and brewed up an unusual snowstorm for April Fool's Day. The technical sessions on Friday and Saturday were well attended and the papers presented called forth spirited discussion.

The meeting started enthusiastically with the report of the membership chairman, Monroe Harris, announcing a 50 per cent increase in the Section since the 1948 spring meeting. Chairman John Rauscher, presiding over the day's technical session, introduced George Swem, Permutit Co., who discussed three methods for "Removal of Fluorides from Water Supplies." H. V. Smith, of the University of Arizona and a pioneer in the field of research on this problem, discussed the paper and the progress in the science and acceptance of defluorination. He also described briefly the world's largest phosphatic absorbent plant, located at Climax, Colo., where the fluorine content of the water is reduced from 23.0 ppm. to less than 1.0 ppm.

John C. Luthin, water superintendent of Santa Cruz, Calif., discussed the public relations policy of a small water department and outlined the use of A.W.W.A. materials in his program.

Arizona Section Director A. W. Miller reported at the Friday luncheon the activities and progress of A.W.W.A. during the past year.

Walter C. Harford's informal discussion of concrete pipe followed the luncheon meeting and dealt with the manufacture and use of different types and connections for pressure concrete pipe. M. E. Devine, Tucson water department, discussed his successful efforts in the repair of concrete reservoirs.

The remainder of the Friday session was devoted to a panel discussion led by A. W. Miller of such topics as in-service training of water works personnel, schools for operators, voluntary mutual aid, the value of

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A.W.W.A. specifications and the proper use of A.W.W.A. public relations material.

At the Friday night dinner, held at the Hassayampa Hotel, Byrl D. Phelps, San Diego, acted as master of ceremonies. Musical entertainment was provided and a color portrayal of the proposed Central Arizona Irrigation Project was featured on the program.

The Saturday morning session opened with a paper and discussion by T. R. Mackay, chief engineer of Fairbanks-Morse Co., of "Horizontal and Vertical Pumps and Their Applications." The morning session was concluded with a report and description of the Prescott water supply by Stuart Henderson, superintendent, and Cecil Overstreet, engineer. The growth of the supply was traced from one well and a hand pump in 1864 to the present abundant supply assured by the development of wells in the Del Rio Valley nineteen miles north of Prescott.

Using as his topic the familiar slogan "Silent Service Is Not Enough," the Rev. Charles Franklin Parker addressed the group at the Saturday luncheon. He lauded the continuing program of improvement and expansion of the water works industry but stated that too often the consumer was unaware of the many services rendered by the industry. Stating that "publicity should be as strong as chlorine and as palatable as maple syrup," he urged that a good public relations program be utilized by all privately and municipally owned utilities.

Under the direction of Guy A. Rhoads and John Hoover, the operators met in closed session Saturday afternoon for a panel discussion of their mutual problems. By unanimous approval of the operators, the half-day Roundup will be included on all future programs of the Section conferences.

At the parallel session Saturday afternoon, John C. Luthin led a panel discussion on "Cost Engineering in Water Works Practice" (this issue, p. 496). At the business session held Saturday a resolution was adopted requesting the Arizona State Dept. of Health to conduct a survey to determine the extent and source of apparently increasing nitrate nitrogen in well water supplies in the Salt River Valley.

Delegates gathered Saturday evening in the lobby of the Hassayampa Hotel where they were the guests of manufacturers' representatives at a cocktail party. The manufacturers' representatives were also hosts at the dance which followed dinner. Informal fellowship was the keynote of the traditional Select Society of Sanitary Sludge Shovelers Dinner, where Dusty Miller (pH 7) acted as master of ceremonies. New members who were added to the roster of the Select Society were Stuart Henderson, Local Arrangements Chairman; Ruskin T. Gardner, retiring F.S.W.A. Director; and J. H. Roberts, Prescott Chamber of Commerce. W. H. Wisely, Executive Secretary, Federation of Sewage Works Associations, a member of several years standing in the Society, was presented with a souvenir

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stone slab, weighing 500 pounds, carrying a message in Indian pictographs.

On Sunday morning members were conducted on a tour of the newly developed Prescott water supply at Del Rio and the treatment plant. It was announced that the Fall Conference of the Section would be held in Yuma, November 11–13, 1949, with the San Carlos Hotel as headquarters. Reservations may be placed now through K. M. Bassett, Box 311, Yuma.

MRS. HELEN ROTTHAUS
Secretary-Treasurer

Indiana Section: The Indiana Section held its 41st Annual Meeting at the Lincoln Hotel in Indianapolis on April 20–22, in affiliation with the State Board of Health. The total registration of 265 was the largest of record, and over 50 per cent of the section membership attended the meetings.

The session was called to order Wednesday afternoon by Clyde E. Williams, Chairman. With Marshall P. Crabill presiding, C. T. Kaiser, sanitary engineer with Jeffrey Mfg. Co., presented a paper on "Flocculation" and discussed scale model testing for equipment design. John E. Kleinhenz, publicity director for the Indianapolis Water Co., talked about the production and use of home-made movies in public relations work before showing "At Your Service, Willing Water." John J. Carroll presided at the Buffet and Smoker, where George E. Symons appeared as Master of Ceremonies for his own "Here and There" give-away quiz show.

Thomas J. Burrin wielded the gavel Thursday morning while B. A. Poole, chairman of the National Committee on Disinfection of Water Mains, discussed the various sections of "A Procedure for Disinfecting Water Mains" as originally published in the February 1948 JOURNAL (p. 131). He further commented on activities and discussions of the Committee in recent months, with particular reference to their developing attitudes toward packing materials. Speaking on the subject "Air Conditioning," Frank C. Amsbary, Jr., Manager of the Illinois Water Service Co., reviewed some of the work and findings of his committee which has been considering the regulation and conservation of water used for air conditioning. Short papers of discussion were read by George G. Fassnacht, Telford R. Davis, Daniel P. Morse and G. V. Savage.

At the luncheon meeting B. A. Poole presented H. E. Jordan who spoke briefly about the internal workings of the New York office as the Association functioned to serve its membership. Charles H. Bechert reconvened the meeting after lunch to hear a paper on "Water Main Extensions" by Fred R. Witherspoon, senior engineer, Public Service Commission of Indiana. Lewis S. Finch acted as moderator for a panel discussion of this paper in which Harry J. Draves, Jack Gordon and

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Everitt Robbins took part. Melvin P. Hatcher, director of the Kansas City Water Department, then presented his talk on "Planning for the Future" which was discussed by J. B. Wilson and Paul Frame.

Guests at the evening dinner were entertained by the Purduvians, members of the Purdue University choral group. The speaker of the evening was Joseph L. Quinn Jr., who gave interesting and amusing sidelights on "The Great Hoosier Spectacle—500 Mile Race."

During the final session Thomas J. Burrin presented a discussion on "Rate Increases," followed by formal comments from David P. Backmeyer and Henry B. Steeg. W. G. Keck, Layne-Northern Co., illustrated his paper, "Preliminary Studies on a Method for Determining Aquifer Permeability by Electric Logging," with slides and diagrams.

Clyde E. Williams presided at the business luncheon at which committee reports were heard. A resolution expressing sympathy and regret for the passing of William C. Mabee, a charter member, past-chairman, Fuller Awardee and Diven Medalist, was accepted and passed. Lewis S. Finch, chief engineer of the Indianapolis Water Co. and past-chairman, section and national committeeman, was given the 1949 Fuller Award in recognition of his application and teaching of sound and ethical practices in the water works field.

George G. Fassnacht
Assistant Secretary

Nebraska Section: The spring conference of the Nebraska Section opened at the Cornhusker Hotel, Lincoln, on April 21, in joint session with the Utilities Section of the Nebraska League of Municipalities. With Harry L. Morris, Chairman of the Utilities Section, presiding, the address of welcome was given by Mayor Clarence G. Miles, who graciously complimented utilities men in general on providing efficient and low-cost service to the public. The technical papers which followed that day were devoted to electrical topics, but one paper on "The Missouri River Basin Project" presented by E. J. Kickinson of the Bureau of Reclamation proved interesting to water works men also, and all registrants were guests at luncheon of the Superior Engine Div. of the National Supply Co.

At the banquet that evening, W. Victor Weir as principal speaker observed that, although he was representing the A.W.W.A. and was primarily interested in sanitary problems, there are many similarities between electric and sanitary utilities, and he offered many humorous and thought-provoking suggestions along that line. Section Chairman Guy E. Bell of Fairbury presided over the Friday program, which was begun with a paper on "Fluorine in Public Water Supplies" by a dentist, Edmund J. Dailey, who suggested that fluorine addition was a matter which would have to be considered and settled by water works men. C. E. Georgi,

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Univ. of Nebraska professor of bacteriology, explained "Bacteriological Tests" to the small water works operator.

George S. Trees of the Chicago Bridge and Iron Co. discussed "Welded Tank Construction," and after luncheon the motion picture "Installing Cast-Iron Pipe" was shown by courtesy of the Cast Iron Pipe Research Assn. "Sewage Disposal" was the subject of a paper by Vern Livingston, manager of the Sidney Public Utilities, and Thomas M. Davies, attorney of Lincoln, discussed "Municipal Liability for Water Main Breaks."

Roy M. Green, dean, and Niles H. Barnard, chairman, of the department of mechanical engineering at the Univ. of Nebraska, presented their report on the Second Annual Water Works Conference held at the University in cooperation with the Utilities Section and the A.W.W.A. in February. The program closed with a business meeting at which Chairman Bell presided. A resolution offered by John Cramer in support of a state appropriation to the University's budget was adopted. A smoker and buffet dinner in the evening concluded the meeting.

J. W. CRAMER
Secretary-Treasurer

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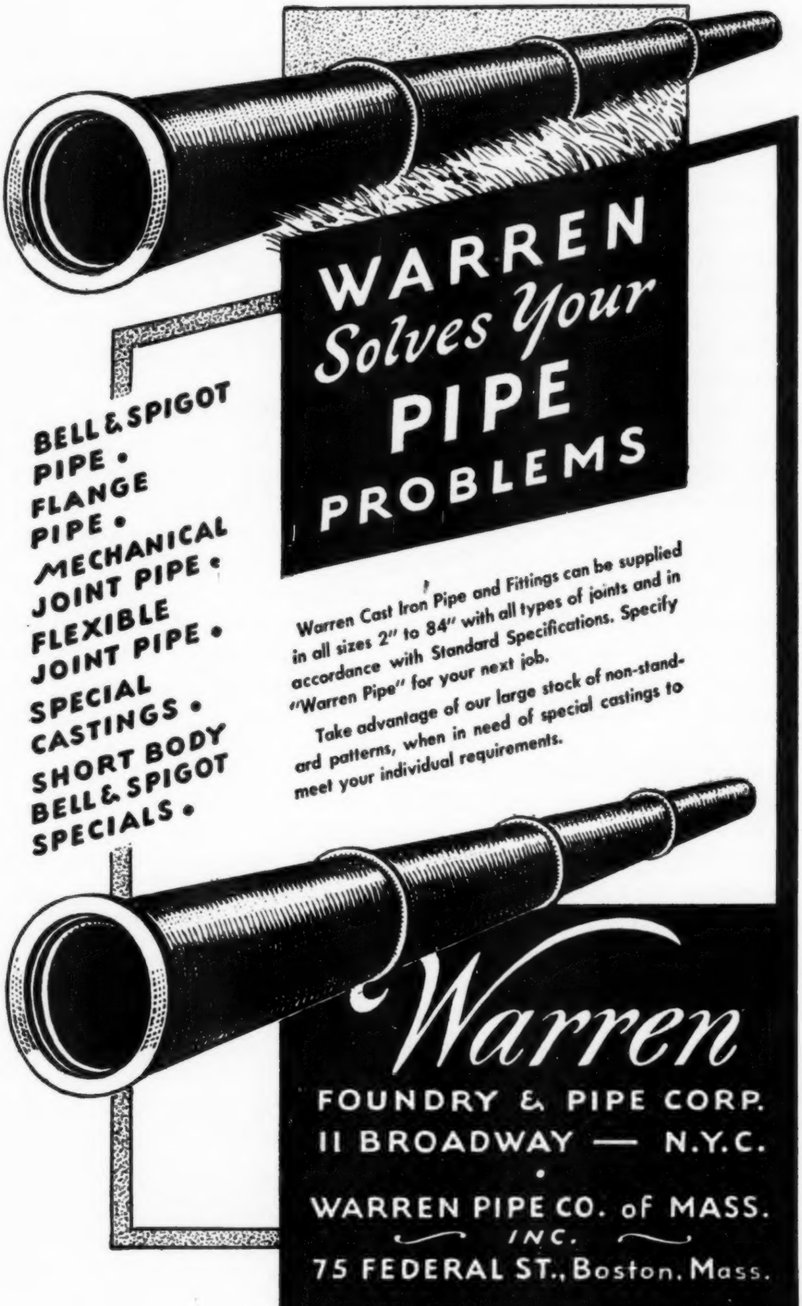
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Montana Section: The twenty-fourth meeting of the Montana Section convened at the Council Chambers in Great Falls on April 8, 1949, with a total registration of 166, which topped all previous convention attendance of the section. The meeting was opened under the able direction of Chairman John Hazen. Jhalmer C. Johnson, Mayor of Great Falls, welcomed the group to the city. W. Victor Weir, Vice-President Elect, discussed the business and problems confronting the national Association. The Section then stood in silence for a minute in remembrance of Al Heath, a long-faithful member who passed away just a few days before the meeting. Talks by Chairman Hazen, Director John Hall, Secretary-Treasurer C. W. Brinck, and committee reports and the appointment of committees completed the morning session of the first day of the meeting.

The afternoon session was given over to a round-table discussion led by M. F. Dixon. A good deal of this discussion concerned the freezing of water pipe lines, since many of our water departments were affected by the very severe winter through which we have just passed. This discussion was led by Harry McCann, superintendent of the Missoula Water Dept., who described the problems with which his system was forced to contend in order to prevent the freezing of their entire water distribution system. Other subjects discussed included water rates, weed control near reservoirs, and the location of leaks. Following the afternoon session, a Dutch Lunch was held at the Great Falls filter plant, at which time the building was inspected. The local staff did an excellent job of entertaining the group. This plant, the largest of its kind in Montana, was viewed with much interest by operators from other localities.

On Saturday, April 9th, Carl Davis, corrosion engineer for the Montana Power Co., discussed "Corrosion of Buried Metals." This paper evoked a great number of questions from the audience. Harry Faber, Research Chemist for the Chlorine Institute, discussed "Water Chlorination in Principle and Practice." The afternoon session began with a discussion on "Nuclear Fission Products and Public Water Supply" by C. W. Brinck of the State Board of Health. Francis I. Livingston, Director of the Div. of Dental Health of the State Board of Health, discussed fluorine in drinking water. A paper by W. Victor Weir on water main extensions and financing brought forth much discussion.

It was decided to hold the next annual meeting in Missoula, Montana. It was also decided that the School for Water and Sewage Plant Operators would be held in Bozeman at the Montana State College sometime between October 15th and December 15th of this year, the exact dates to be decided after consultation with the college officials. The convention concluded with a dinner-dance which was held at the Rainbow Hotel in Great Falls.

C .W. Brinck
Secretary-Treasurer

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